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OPERATIONS RESEARCH

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Operations Research is the application of research techniques to the study of the operations of war and peace. It examines what occurs when a team of men or machines does the job assigned to it. It is an activity; a pattern of operations, susceptible of being related to other diverse activities. Its applications encompass such unrelated matters as determining time of waiting in line in a restaurant; fixing the interrelations between sales fluctuations, size of inventories, and production scheduling; or developing a pattern of search operations for an enemy submarine or aircraft.

THIS is a progress report on a relatively new branch of applied science. First utilized during World War II on military problems, it proved valuable enough so that most military staffs, here and in England, now have operations-research groups. More recently its usefulness in industry is coming to be recognized, and groups are also being attached to top industrial staffs. The Operations Research Society of America, formed two years ago, now has nearly 1000 members; its Journal is now in its second volume. What is this new activity, and how is it related to other branches of science and engineering?

Defining a branch of science in a few, nontechnical terms is not easy. Perhaps the safest definition is that Operations Research is the activity carried on by operations-research groups and reported in the Journal of the Operations Research Society of America. But often some less circular sort of definition is desirable. Students who may wish to learn about the field have to be told what it is; people want to know what it's good for; workers in related fields want to know why it should be differentiated from their own fields, and so on.

WHAT IS OPERATIONS RESEARCH?

Operations Research has been defined as the application of the scientific method to problems of management, but this is obviously too concise and too general a statement. There are many sorts of "scientific methods," and many sorts of people study problems of management. Part of the definition must describe the way these problems are studied. Here the word "research" in the title may give a hint. The research scientist, at least in the physical sciences, uses the quantitative language of mathematics, employs the well-known but difficult-to-describe procedures of experimentation and theory making. He looks at the phenomenon he is studying in a certain impersonal way, being more interested in *how* than in *whither*, more interested in *why* than in *for what use*. Many centuries of experience have taught him that this impersonal viewpoint, this dual employment of theory and experiment, will usually procure for him results of value in his science and that too great a preoccupation with questions of the worth of the result, or the immediacy of the need, will actually hinder his progress.

Operations Research, then, is the application of research techniques to the study of the operations of war and peace. It is concerned with an attempt to understand something, in the scientific sense of the word understanding. It is an effort to discover regularities in some phenomenon and to link these regularities with other knowledge so that the phenomenon can be modified or controlled, just as other scientific research does. The difference comes in the phenomena which are studied, the subject matter. Instead of studying the behavior of electrons or metals or gasoline engines or insects or individual men, Operations Research looks at what goes on when some team of men and equipment goes about doing its assigned job. A battalion of soldiers, a squadron of planes, a factory, or a sales organization is more than a collection of men and machines; it is an activity, a pattern of operation. These operations can be studied, their regularities can be determined and related to other regularities; they can eventually be understood, and they then can be modified and improved.

RESEARCH AT THE OPERATIONAL LEVEL

Operations Research is concerned, not with matter or with individual machines or with men, but with the operation as a whole; with battle tactics, with strategic and logistic planning for future operations, with the interrelation between sales fluctuations, size of inventories, and production scheduling, with the flow pattern of goods in a group of factories or of traffic in a city, to mention a few examples. We might use the word "level" to distinguish between the different subject material, if we can divorce the word from any connotation of relative importance or difficulty. Physics and chemistry would then correspond to research at the basic or material level; the study of bridges and television sets, research at the engineering or applied level. Operations Research would then be *research at the operational level*.

Although the name is relatively new, research at the operational level is not new, of course. Taylor and his followers, in their time and motion studies, have investigated a small part of the

whole field; traffic engineers have been working on another part; systems engineers encroach on it, and so on. Perhaps the most useful service the new term Operations Research has performed is to emphasize the essential unity of the whole field, to force the recognition of similarities in behavior in areas hitherto separate, and to make apparent the broad usefulness of a number of research techniques and mathematical models.

TECHNIQUES USED

I have not yet said anything about the techniques used in Operations Research. As with other research, any technique of measurement or of calculation, any portion of a basic science is used which will produce results. We should expect that the theory of probability and of statistics would be very useful tools; we should also expect that the techniques of the psychologist would be needed in other cases. This does not mean that Operations Research is applied statistics on the one hand or is a branch of social psychology on the other. It uses any and all of these disciplines to study operations in order that they may be understood and thus controlled. Since a wide variety of basic science is involved, much of the research can best be carried on by a team of workers having a variety of background training, each contributing his specialized knowledge to the solution of the operational problem. The advantage of a mixed team for the study of many operational problems is obvious. In fact, some persons have said that the use of mixed research teams is a characteristic of Operations Research. It certainly is important in many investigations; whether it is characteristic or necessary might be questioned.

But certainly further generalities will not be helpful here; a few specific examples may help clarify the picture. Certain particular aspects of operations have been the subject of intensive study in the last few years, and special mathematical models have been developed to help understand the phenomena. As is usual with models, they represent only part of the phenomena, and since Operations Research is new, most of these models need further development before they can be satisfactorily general in their applicability. Here the Operations Research worker needs the help of the basic scientist, particularly the mathematician.

WAITING IN LINE

Take the simple business of waiting in line—the British call it queuing. All of us do it too much of the time: if we drive to work in the morning, we wait at traffic lights; if we go to a cafeteria at noon, we wait for our lunch. It is the headache of many businesses; it is a vital problem for airlines when an airport clouds in and the planes begin to stack up, waiting to land. Let us see what can be said about this sort of problem.

We start as usual with a fantastically simplified case; one where the front of the line is served at some constant rate, say S per second, and where the rear of the line is being filled up by people (or planes) coming in at random times but with an average rate of arrival, A per second. We will also assume that this has been going on long enough so that a steady state has been reached; we can consider the transient case as a later elaboration. The key to this mathematical model lies in the working out of the various probabilities that the line will have zero, one, two, or n persons in it. Call the probability that there are n persons in the line P_n.

If P_{10} is large, for example, this means that we are quite likely to find ten people ahead of us when arriving in line; what the restaurant tries to do is to make P_0 large.

To have a steady state, none of the P's should change with time. But every time a person arrives, all the P's step up by one, P_0 changes to P_1, and so on, and every time a person is served, they all change downward. So, in order that A persons arriving a second and S being served a second will not continually change the probabilities, they must be related in some special way. For example, the rate of disappearance of a line of zero length is AP_0, the rate of arrival times the chance that a zero length line is there; the rate of appearance of a line of zero length is SP_1, the rate of serving times the chance that a single-length line is present. To have a constant probability of zero-length line, we must have these two rates balance; $AP_0 = SP_1$. Similar balance for lines of unit length, of length n, and so on, gives rise to the sequence of equations

$$AP_0 + SP_2 = (A + S)P_1; \qquad AP_{n-1} + SP_{n+1} = (A + S)P_n$$

and so on.

These can be solved without much trouble, giving $P_n = (S - A)(A^n/S^{n+1})$ as long as the rate of serving, S, is larger than the rate of customer arrival, A. It is obvious that if customers are arriving at a rate faster than they can be served, the line *cannot ever* be stationary in length and, if they value their reputation or peace of mind, our restaurant or airport managers must avoid this at all costs. But even when customers arrive more slowly than they can be served, we see that there is a finite chance that a line will form. In fact, the average length of the line turns out to be $A/(S-A)$.

This quantity is quite small as long as the maximum serving rate S is at least twice the arrival rate A. But if people arrive nearly as fast as they can be served, the average waiting line rapidly lengthens; if A is $0.8S$, then the average number in line is 4; if A is $0.9S$, the line has 9 in it, on the average, and so on. For example, if A is $0.8S$, if customers are served 25 per cent faster than they arrive, on the average, then 20 per cent of the time there will be no line, 16 per cent of the time one will be waiting, 13 per cent of the time two will be in line, 8 per cent of the time four will be waiting, 2 per cent of the time ten will be in line, and so on, the average line length will be four.

It may seem peculiar that there should be *any* waiting line when the mean rate of service is greater than the average rate of arrival; this is due to our assumption of *randomness* in service and arrival. We assume that each customer doesn't conveniently arrive just when the last customer has been served, the customers arrive at random, which does *not* mean regularly. Also one customer may take longer to be served than the next, and a bunch of customers every now and then arrive just when a slowpoke is being served. These random mismatches between customer and server don't matter much if the service is considerably faster than the average rate of arrival; once in a long time two or three may come in a bunch, but most of the time no one is waiting. But if customers arrive nearly as fast as the line can be handled, these mismatches occur more and more often, and the chance of a long line occurring quickly is large. Of course, if the servicing process could be made *absolutely* regular, each service completed exactly in ten seconds, for example, and if also we could regiment our customers to arrive exactly ten seconds apart, so that one walked in the door exactly at the end of each ten seconds, then S could equal A, and still no line would form.

But service is very seldom as perfectly timed as this, and we practically never can regiment the arrivals. Customers, automobiles, and airplanes do arrive in a random manner at restaurants, street intersections, and airports, and it turns out that the results of our simple quantitative reasoning fit actuality remarkably well in spite of our preconceptions to the contrary. Here is a case where theory and actuality contradict our intuitive "feelings." In every case where this theory applies, gross errors of estimate have been made regarding the expected length of waiting lines, on the basis of nonmathematical "hunches." Often

long arguments have occurred before the manager would be willing to face the consequences of the theory. They would continue to say, "But why should there be a waiting line when I can serve them faster than they are coming?" in spite of the line which was there before their eyes. The results of such irrational behavior only produce irritation in the case of restaurants, gasoline stations, and the like; it is much more serious in the case of airports or docking facilities in harbors, particularly under wartime conditions.

INDUSTRIAL PROBLEMS

The simple theory, sketched so quickly above, can be expanded and complicated almost indefinitely. For example, the problem of machine maintenance in a factory is of this sort: the machine can be said to "arrive in the waiting line" when it breaks down; it is "served" when it gets repaired. The flow of parts through an assembly line is another example. The theory can tell us how many parts must be kept on hand at each stage of the process, in order that no machine should be kept idle by delay in the earlier processing, for example. Many aspects of the over-all problem of industrial inventories also can be analyzed by this technique. Here it is the sales, the outflow, which has the large fluctuations; we need to balance between the requirement that orders be filled as soon as they come in and the added expense of running a factory overtime if our inventory runs out.

Another sort of problem which turns up in a large number of operational studies has to do with the optimization of some function of a number of variables, subject to boundary conditions which limit the variables' range. For example, an oil company can produce various proportions of fuel oil, gasoline, and aviation fuel from their cracking plants, depending on the kind of crude oil they use, and can produce various proportions of these end products from a given crude, depending on the cracking process used. But crudes differ in price, and cracking processes differ in cost. Suppose the company has orders for definite quantities of end products to be delivered in the next three months. What amounts of which crude shall it buy, and which processes shall it use in its cracking plants, to produce the required amounts of products at the least cost, subject to limitations of supply of crudes and of output of their plants?

The variables here are the various amounts of crudes to be bought and the degree of utilization of each plant. The function to be minimized is a linear function of these variables, and the limits on each variable are accurately known. Such a problem is known as a *linear programming* problem. There are many such problems which turn up in Operations Research. Techniques of solution are not simple, and many of them require high-speed computing machines; much further mathematical research is needed to simplify computing procedures in linear programming calculations.

Parenthetically, the optimization of the crude-oil-cracking problem has been worked out by the research or the engineering departments of many large oil companies. The persons who worked out those solutions did not call what they were doing Operations Research; many of them had not heard of Operations Research. It is also true, however, that most of these workers were not aware that many other problems in the company's operations were also amenable to the same analysis. The value of the concept of Operations Research to these companies lies in making their research men aware that the techniques of theoretical analysis they have been using for one problem can be applied to a much wider range of operational problems than they had hitherto conceived, and in showing the company executives that they can use their own research departments to help solve production and sales and distribution problems, where they had not hitherto been used.

LINEAR PROGRAMMING

The linear programming problem can be visualized most simply in geometrical terms. The n variables define an n-dimensional space; a point of this space corresponds to a solution. Each limitation on the range of the variables corresponds to a hyperplane in this space, restricting the allowed solution points to one side of the hyperplane. By the time we have finished specifying all the restrictions (negative production not allowed, maximum limits on storage capacity, limits on production, and so on) we find we have surrounded the region of possible solution by hypersurfaces, so that the allowed region is the interior of a convex polyhedron in the hyperspace. If the function to be optimized is a linear function of the variables, then the requirement that this function have some constant value also corresponds to a hyperplane which may or may not cut through the polyhedron; if it does, it then corresponds to an operationally possible value of the function to be optimized. By changing the value of the constant, we can generate a family of hyperplanes parallel to each other, their distance from the origin being proportional to the value of the function to be optimized.

Some of the hyperplanes in this family cut through the polyhedron containing the region of solution, some do not. There are two limiting hyperplanes, one corresponding to the largest value of the function for which the hyperplane just touches the polyhedron, and one corresponding to the smallest value which just touches. Consideration of the geometry shows that for most orientations of the family of planes the two limiting planes just touch a vertex of the bounding polyhedron and thus contain just one possible solution compatible with all the boundary conditions. The outermost limiting point is the optimum solution if the function is to be maximized; the innermost point is optimum if the function is to be minimized. Once the geometry is clear in one's mind, it is easy to visualize the solution. But, at present, it is not easy actually to compute the optimum vertex when there are several dozen variables and about a hundred boundary faces of the polyhedron.

PRODUCTION PLANNING NEEDED

Important as linear programming techniques are, they need further generalization to be able to solve many problems in Operations Research. Production planning is an example. A factory can produce so many units of some product each month, but sales of the product are small during the summer and very large in December, so large that fall production cannot equal December sales. One solution is to run the factory overtime during the fall; but overtime production costs more than normal output. Another solution is to produce more during spring and summer and store it ready for the winter rush; but warehousing also costs money, in storage and handling charges and in interest on the money tied up. A third solution, of course, is to fail to meet orders in December, but this is a council of despair.

It should be evident by now that this is also a linear programming problem. The variables are the regular production each month and the overtime production each month. The excess of production over sales each month is warehoused. The boundary conditions are the limits on the production and overtime production each month and the additional requirements that the total production from the first of the year shall never be less than total sales from the first of the year. The quantity to be minimized is the total cost, including overtime charges and warehousing charges.

As stated, this is a straightforward linear programming problem, *if* we can predict exactly our sales throughout the coming year. If our sales forecast is exact, we can proceed to find the distribution of production and overtime production each month

to minimize total costs and to satisfy all forecast sales. The trouble is we never know exactly what the sales are going to be, and if we have underestimated them, we will not be able to meet orders; if we have overestimated them, we will end the year with unsold products in our warehouse. All we really have is a probability distribution of expected sales; to put it pictorially, some of the sides of the bounding polygon are fuzzy, not sharp.

PROBLEMS OF "BOUNDED OPTIMIZATION"

At present, our techniques of solution are not adequate for such problems, nor are they if the function to be optimized is not a linear function of the variables. Such more general problems might be called problems of *bounded optimization*. The problems are clear, but a great deal of further analysis and devising of computational techniques is needed before solutions can be obtained with the requisite ease. Speed of solution is needed here, for in many cases we wish to find a whole sequence of solutions as we vary some of the limits: what happens if we build another factory, or if we close down our factory in August, for example. When solutions of problems of bounded optimization are easy to obtain, many tough problems of planning of production, of sales effort, of logistics, and so on will be easier to solve.

Another kind of problem for which a mathematical model can be built, came up first in naval operations research, but has numerous business analogs. It concerns the operation of *search* for an enemy vessel, or submarine or aircraft. The enemy is somewhere in a given area of the sea. How do you deploy your aircraft to find him? The central idea here is the *rate of search*. A single plane can see the enemy vessel (by radar or sonar or visually, as the case may be) R miles away, on the average. The plane can "sweep" out a band of width $2R$ as it moves along; the picture is analogous to a vacuum cleaner, of width $2R$, sweeping over the ocean at a rate equal to the speed of the plane and picking up whatever comes beneath it. An area equal to the speed of the plane times twice the mean range of detection will thus be swept in an hour. The sweep rates of planes vary from a few hundred square miles per hour to several thousand square miles per hour, depending on the plane, the radar equipment, and the vessel searched for.

If the enemy is equally likely to be anywhere within a certain area, then the problem is a straightforward, geometrical one. The search effort is evenly laid out over as much of the area as one has planes available. The problem is a little complicated by the fact that detection is not certain at extreme ranges, so the probability of detection falls off near the edge of the swept band and there should be a certain amount of overlap between bands to improve the chance of detection near the edges.

But if the chance that the enemy is present varies from area to area, the problem becomes quite difficult; nonmathematical intuition may lead to quite erroneous use of available effort. For example, if the enemy is twice as likely to be in one area as in another, then, if only a small amount of search effort is possible, *all* this effort should be spent in searching the more likely area; if more effort is available, some time can be spent on the less likely area, and so on. A definite formula can be worked out in each specific case. Search plans for various contingencies were worked out by the Operations Research team attached to the Navy during the war; they materially aided the naval efforts in many cases.

FROM WAR EFFORT TO INDUSTRY

It seems a far cry from planes and ships and submarines to industry and business activities. But the utility of the mathematical models is their wide range of applicability. One possible business application of search theory comes in the problem of assignment of sales effort. Suppose a business has a limited number of salesmen who are to cover a wide variety of dealers. Some of these dealers are large stores, which will usually produce large orders when visited; some are small stores with correspondingly smaller sales return. If there are enough salesmen, every dealer can be visited every month, and the optimum number of sales can be made, although the sales cost will be high. With fewer salesmen available, search theory indicates that the larger stores should be visited more often than the small stores; with very few salesmen it may be that only the large stores should be visited. If the probable return per visit for each store is known, the optimum distribution of sales effort can then be calculated.

An interesting and typical variation on this problem comes when we consider the action of the individual salesmen, when we try to make their behavior conform to the best over-all distribution for the company. For each individual salesman, with his limited effort, it may be best *for him* to visit only the large stores; if his visits are uncontrolled and if he is paid a flat commission, it may turn out that the large stores are visited too often, the small stores too seldom, for best returns *for the company as a whole*. It then becomes necessary to work out a system of incentive commissions designed to induce the salesmen to spread their efforts more evenly between large and small customers. If the general theory has been worked out, this additional complication can be added without too much difficulty.

This problem of balancing the tendencies of different parts of a large organization is one which is often encountered in industrial Operations Research. The sales force is out to increase sales of all items, though some items may return less profit than others; production resists change-over to making another product, though sales on the other product are increasing; and the financial department frowns on building up large inventories, though small inventories always put the production division at the mercy of sales fluctuations. It is often not too difficult to suboptimize each of these divisions separately, so each is running smoothly and effectively as far as its own part of the business is concerned. But to be sure that all these parts mesh together to make the company *as a whole* operate most efficiently requires much more subtle analysis and very careful quantitative balancing.

In the interest of reducing factory overtime and to keep down inventory, for example, it may be necessary to modify the salesman's incentive commissions, so he will be induced to push one line over another. It may be necessary for the production division to allow more overtime in one department than another, to make some part of its operation run at less than optimum in order that the over-all operation be optimum; and one must take care not to penalize the production department, by reduced bonuses or the like, for reducing its efficiency so that the effectiveness of the whole is improved.

A BETTER UNDERSTANDING OF OPERATIONAL PROBLEMS

But perhaps these few, simple examples are enough to show you that the research techniques developed to increase our understanding of the nature of the physical world can also be used to help us understand operational problems. In many cases in industry and war, a simplified quantitative model of the situation can help us see what goes on and can help us devise the best way to proceed. In many cases, it is not necessary to have a complete picture of all that goes on, clear down to all the basic details. As long as our mathematical model can be adjusted to fit some of the regularities which appear, we can abstract these parts of the behavior from the rest and study them separately. The process of abstraction, of keeping clear of local details, has the advantage of providing a model which may fit a variety of circumstances; restaurants, production lines, or landing aircraft. By gaining in generality, of course, we lose in detail.

Perhaps you can also see that such methods can probably not

be used to solve *all* problems. Just as it is quite unlikely that the methods of analysis used so successfully in genetics can be used to solve all biological problems, for example, so it is unlikely that the Operations Research scientist, with his specialized techniques of analysis, can ever replace the usual business executives or army generals with their practical experience and their intuitive grasp of the complicated effects of morale and applied psychology, for example.

But as the new techniques are tried in more and more different fields, it should become clear what operational situations can be analyzed by its means and what situations cannot. Already there are Operations Research teams working closely with military and industrial administrators, exploring these possibilities, reporting their findings to the administrator so that he may be able to combine their quantitative results with his experience and judgment to reach more understanding decisions.

Scientists and engineers have not, in general, been active in administering government or business. This is not surprising, for the business of science is to understand, not to act. But in Operations Research, however, there is an opportunity for scientists and engineers to help in administrative problems, not by becoming the administrator, but by providing the administrator with quantitative understanding of aspects of his operational problems so that he can reach a wise decision, fully conscious of the implications of his choice.

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de Kováts, A., and Desmur, G., Pompes, ventilateurs, compresseurs. Centrifuges et axiaux, Paris, Dunod, 1953, viii + 336 pp.

L'Hermite, R., Résistance des matériaux. Théorique et expérimentale, vol. I, Paris, Dunod, 1954, xvi + 860 pp., 384 figs. 8400 Fr.

Van Santen, G. W., Introduction to a study of mechanical vibration, Eindhoven, Philips' Technical Library; Houston, Elsevier Press, Inc., 1953, xvi + 294 pp.

Lee, J. F., Theory and design of steam and gas turbines, New York, McGraw-Hill Book Co., Inc., 1954, xiv + 502 pp. $9.

Beyer, R., Kinematische Getriebsynthese, Berlin, Springer-Verlag, 1953, vii + 217 pp. DM 36.

Peterson, R. E., Stress concentration design factors, New York, John Wiley & Sons, Inc., 1953, x + 155 pp. $8.50.

Goody, R. M., The physics of the stratosphere, New York, Cambridge Univ. Press, 1954, x + 187 pp. $5.

Roark, R. J., Formulas for stress and strain, 3rd ed., New York, McGraw-Hill Book Co., Inc., 1954, xiv + 381 pp. $7.50.

Bäckström, M., Kältetechnik, Karlsruhe, Verlag G. Braun, 1953, xvi + 649 pp., 373 figs.

Letters to the Editor

671. Concerning AMR 6, Rev. 3267 (October 1953): E. Hovmöller, A comparison between observed and computed winds with respect to their applicability for vorticity computations.

Instead of ". . . . based on unobserved winds. . .", read ". . . . based on observed winds. . .".

Theoretical and Experimental Methods

(See also Revs. 709, 713, 725, 727, 728, 738, 828, 834, 835, 844, 845, 916, 934, 949, 987)

672. Menzel, D. H., Mathematical physics, New York, Prentice-Hall, Inc., 1953, vii + 412 pp. $8.50.

There are already many fine and time-tested textbooks on classical mathematical physics. There is doubtless room for one more, particularly one as lucid as this book by Prof. Menzel.

The book is intended for use in junior, senior, or graduate (presumably, first year) courses and it is expected that the student is prepared with a good working knowledge of differential and integral calculus. During the first few years of undergraduate studies the science student encounters mathematics and physics as somewhat separate subjects. Books on mathematical physics such as the present one are designed to join the two subjects by demonstrating the value of the systematic exploitation of mathematical methods in physics. The task of orienting the theoretical discussions with respect to the findings of experimental physics is commonly left to the teacher or to other courses.

In part I there is a discussion of physical dimensions and the fundamental units of importance in physics, followed by a rudimentary treatment of dimensional analysis. Part II (156 pages) alternates sections on the principles of mechanics, the theory of the potential, hydrodynamics, and the principles of advanced dynamics with sections discussing the appropriate mathematical tools of vector and tensor analysis.

Part III deals with the wave equation, vibrations in mechanical systems, the effects of damping in vibrating systems, and boundary-value problems in heat flow. This very interesting part includes, as a foretaste of quantum mechanics and L'Hermite polynomials, a short treatment of the case of a vibrating string with complex wave velocity.

Part IV presents the fundamentals of electrostatics, magnetostatics, electromagnetism, and electromagnetic radiation. The inclusion of several sections devoted to certain topics in the theory of electrons is considered particularly noteworthy. A topic commonly treated, namely, the interaction of steady currents, has been omitted, however. The key formulas in part IV are presented in both Gaussian and rationalized MKS units.

The book closes with a 34-page discussion, part V, of the theory of relativity. There is included a well-written section on the fundamentals of general relativity, a topic not commonly treated in such texts.

For the most part, the solutions to the problems presented for exercise are straightforward and reasonably short. The answers are frequently given and many important results to supplement the text are included. These facts coupled with the unusually detailed treatment of selected topics and examples recommend the book as being particularly valuable for the student who must work alone. Because of the greater space given to analytical demonstrations in the text, author omits several topics usually included, principally thermodynamics and statistical mechanics. The reviewer does not consider these omissions too serious, however.

In conclusion, it is expected that this well-prepared textbook

will be welcomed by many students and teachers as an excellent exposition of the principles of mathematical physics.

M. Alperin, USA

673. Shortley, G., and Williams, D., Elements of physics, New York, Prentice-Hall, Inc., 1953, xiii + 778 pp. $7.50.

Book has been written for use as a text in an introductory course in physics, such as is normally taken by students of science and engineering. The material and manner of presentation are especially commendable. Authors have conveyed an understanding of the basic physical phenomena clearly and concisely. The inclusion of two chapters on modern physics enables the student to gain some insight into the theories and experimental work which have been carried on since the beginning of the 20th century. There are numerous examples and problems which are helpful to the successful application of empirical or derived relationships. The appendix gives a particularly good collection of fundamental physical constants, mathematical tables, and conversion factors. Units have been presented in a coherent, consistent manner.

G. V. R. Rao, USA

674. Duschek, A., Lectures on advanced mathematics [Vorlesungen ueber hoehere Mathematik], vol. III, Wien, Springer-Verlag, 1953, ix + 512 pp. $8.70.

The present volume on ordinary and partial-differential equations, variational principles, and complex variable theory might be considered as the long-expected missing link which should satisfy the demand for rigor by the abstract mathematician as well as the ever-increasing needs of today's physicists and research engineers.

Author deals successively with three main chapters of advanced analysis, the ordinary and partial-differential equations, the calculus of variations, and the theory of the complex variable. Concerning the first part, author expresses his admiration for the presentation of the same subject by Kamke and follows the classical text in many ways. Rather original, however, is the desire of the author for imaginative geometrical interpretations prevailing throughout this section of the book. The structure of the solutions of differential equations and their singularities are analyzed in a concise way, avoiding too many details and unnecessary excursions. The usually dry chapters on the meaning of characteristics for the particular and general solutions of partial-differential equations are interesting. Existence theorems are presented where really necessary. But it is author's aim to deduce solutions rather than merely to predict them.

The second part leads the reader into the innermost regions of the variational calculus. It is in this section that the author finds his chance to develop his most original ideas. General coordinates and spaces are analyzed, contravariant and covariant vectors are introduced. The invariance of the Euler equations is established and the foundations of Riemann geometry laid. The Hilbert independence theorem plays an important role. The reader is finally guided into the Jacobi-Hamiltonian theory. The Hamilton principle of general dynamics is illustrated in the case of planetary motions.

The last part of the text is devoted to the theory of analytic functions. Of specific interest to the applied mathematician are the well-presented chapters on integration in the complex plane, residues, and the methods of conformal mapping. No less important are the sections on the nature of whole, meromorphic, and periodic functions, the function z, and the fundamental concepts of analytical continuation. The book concludes with some advanced chapters on elliptic functions and integrals.

A number of interesting examples opening a wide field of applications is added for a better understanding of the more difficult derivations. To the extent the presentation proceeds into the more interior and hidden mathematical domains, the effort on the part of the reader must increase. If there are some details which are rather difficult to understand at once, they become satisfactorily clear further on. Every reader might miss a few topics of specific interest to him, but a book like this one with such far-reaching objective is necessarily a compromise. Also, it is written by one person and not a group of writers, as is usual in such cases. This, on the other hand, undoubtedly is the key to the homogeneity of the text as a whole.

M. A. Dengler, USA

675. Kron, G., A set of principles to interconnect the solutions of physical systems, *J. appl. Phys.* **24,** 8, 965–980, Aug. 1953.

This article is an abstract of G. Kron's work during the past 20 years; it cannot, therefore, be abstracted in a review. It is important to those who are acquainted with that work, as well as to those who are not. To those interested in Kron's work the article is notable for its strong emphasis on the interconnection of given physical systems, and also on the splitting of a given complicated system into separate units, to be analyzed and eventually reconnected. This point of view, by no means absent from Kron's earlier work, seems to be paramount in the latest publications by him and by his followers (it should be noticed that Kron is no longer a lone thinker and that his ideas are put to work by specialists in motor design, interconnection of power networks, mechanical computation, etc.).

To those unacquainted with Kron's work this paper may be an incentive to delve into its study, a most rewarding pursuit if one is willing to cope with Kron's rather forbidding way of writing. Both types of readers will appreciate the complete and analytic bibliography of Kron's papers contained in the footnotes.

P. Le Corbeiller, USA

676. Mazet, R., Application of the global method for the study of certain nonlinear systems (in French), *Publ. sci. tech. Min. Air, Paris* no. 281, 17–18, 1953.

Global method consists of assuming that a physical system under study responds in accordance with some previously investigated general type of system. For instance, it is known that elements f and g in a linear system described by $x'' + fx' + gx = 0$ do not affect the amplitude of response of the system when forced. On the other hand, if we find the system is such that these elements are dependent on the amplitude of response, we may be able to assume that the system is one of a general nonlinear type, called here the van der Pol type. Since, in the van der Pol equation, the coefficients f and g are related to the amplitude of response, we may be able, in general, to assume f and g of the form $f(x) = \Sigma a_\rho(2x)^{2\rho}$, $g(x) = \Sigma b_\rho(2x)^{2\rho}$, where a_ρ and b_ρ are such that the series are known to converge. Reviewer believes that this method is not very conclusively evidenced in the note at hand, that the method would be restrictive, and that, in general, nonlinear physical systems cannot be analyzed in this fashion.

H. G. Cohen, USA

677. Davidenko, D. F., New method for a numerical solution of systems of nonlinear equations (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **88,** 4, 601–602, Feb. 1953.

Author presents nonlinear system

$$f_k(x_1, x_2, \ldots, x_n, \lambda) = 0; \quad k = 1, 2, \ldots n \qquad [1]$$

with a solution

$$x_1 = x_1^{(0)}; \quad x_2 = x_2^{(0)}, \ldots x_n = x_n^{(0)} \qquad [2]$$

for a particular value λ_0 of parameter λ. Under conditions of existence, continuity and non-null Jacobian, system [1] is differentiated to be transformed into

$$\sum_{r=1}^{n} \partial f_k/\partial x_r \cdot dx_r/d\lambda = -\partial f_k/\partial\lambda;\ k = 1, 2, \ldots n \qquad [3]$$

from which we have

$$dx_r/d\lambda = \Delta_r/\Delta = F_r(x_1, \ldots, x_n, \lambda) \qquad [4]$$

Numerical solution of [4] will give parametrical curve

$$x_r = x_r(\lambda);\ r = 1, \ldots, n \qquad [5]$$

through $(x_1^{(0)}, \ldots, x_n^{(0)}, \lambda_0)$.

Parameterless systems such as

$$\phi_k(x_1, x_2, \ldots, x_n) = 0;\ k = 1, 2, \ldots n \qquad [6]$$

may be put under parametrical form [1] by suitable introduction of λ.

Actual interest of method consists in that approximative numerical solutions of ordinary differential equations such as [4] are easier, generally speaking, than classical solution of [1]. System [1] may be an algebraic or transcendant one.

Author's paper was presented by Soboliev and theme proposed by Bogolyubov. J. E. Carrizo Rueda, Argentina

678. Stein, M. L., On methods for obtaining solutions of fixed end-point problems in the calculus of variations, *J. Res. nat. Bur. Stands.* **50,** 5, 277–297, May 1953.

Author presents two methods for obtaining a sequence of solutions to the problem of minimizing an integral for a certain class of arcs joining a pair of fixed points. The Euler equations for the problem are replaced by an integral operator which is obtained by a formal integration of the Euler equations. One method is a generalization of Newton's method for finding the values of a function of a single real variable. If y_1 (reviewer's notation) is an approximate solution to $T(x; y) = 0$, where $T(x; y)$ is the integral operator, x is the independent variable, and y denotes the class of arcs considered, then an "improved estimate" y_2 is found from $y_2 = y_1 + \eta_1$ where η_1 is the solution of $T(x; y_1) + d/d\alpha\,[T(x; y_1 + \alpha\eta_1)]_{\alpha=0} = 0$, under suitable end conditions.

The second method is particularly applicable to quadratic integrands (in the original minimizing integral). An improved estimate y_2 is obtained from $y_2 = y_1 - \alpha_1\eta_1$, where $\eta_1 = T(x; y_1)$, and α_1 is a real number. Author does not claim either technique is a quick computational procedure for desk computers, but that they may be carried out on automatic-computing machinery.

The presentation of the technique and a numerical example of the application of the generalized Newton's method occupy about one quarter of the paper. The rest of the paper is devoted to a number of analytic properties of the operator $T(x; y)$, existence and uniqueness of solutions, and proof of convergence of the sequence of approximating functions. These analytic concomitants are couched in the language of Banach space linear operators in that space, and Lebesgue integration.

H. J. Weiss, USA

679. Langefors, B., An approximate solution of simultaneous equations by means of transformation of variables. Applications to aeronautical problems, *SAAB Aircr. Co., Linköping, TN* 7, 26 pp., 1953.

If the n variables describing a certain physical system are subject to $m < n$ constraints, then allowable values of the variables lie in an $(n - m)$-dimensional subspace. An approximate solution of system equations may be defined as a point of a certain part of the subspace as near as may be, in some sense, to the exact solution point. For linear equations and constraints, useful approximation processes may be carried out by matrix methods. Examples of Ritz, Galerkin, and interpolation methods are stated in these terms. C. M. Ablow, USA

680. Slobodyanskiĭ, M. G., Estimates of errors of approximate solutions for linear problems (in Russian), *Prikl. Mat. Mekh.* **17,** 2, 229–244, Mar.-Apr. 1953.

The present paper is an extension of the author's previous work on approximate methods for linear problems. It expands the results of two previous recent papers [AMR **6,** Rev. 1185; *Doklady Akad. Nauk SSSR (N.S.)* **86,** 243–246, 1952]. The method of approximation is based on a variational principle for operators in Hilbert space. More specifically it gives a method for approximating the inner product (f, v) which simultaneously yields an estimate of the error. In the above inner product, f is an element of a Hilbert space H, v is an element to be sought and lies in a linear manifold M of H. The linear operators under consideration, A, are positive definite, i.e. $(Av, v) \geq C(v, v)$; symmetric, i.e. $(Au, v) = (u, Av)$, and are also defined on $M \in H$.

In the above paper, the operators A are differential operators and the discussion is limited to an ordinary linear differential equation of the nth order and to an operator of the elliptic type (partial-differential equation). In each case the appropriate Hilbert space is defined.

Explicit examples are worked out for the case of boundary-value problems associated with ordinary differential equations. A great deal of the basic material is derived from the works of S. G. Michlin, e.g., "Direct methods in mathematics and physics" [AMR **5,** Rev. 2248]. J. J. Brandstatter, USA

681. Tomaszewski, A., Applications of the theory of probability to fits and clearances of machine elements (in Polish), *Przeglad Mech.* **12,** 1, 6–12, Jan. 1953.

Article is an elementary outline of the theory of fits in machine design. It is well known that the mating at random of the male and female machine element is equivalent to adding two independent random variables. Under the assumption that the distributions are (a) rectangular, (b) triangular, and (c) normal, author shows how to determine the distributions of the clearance.

J. Oderfeld, Poland

682. Williams, E. J., A method of analysis for double classifications, *Austral. J. appl. Sci.* **4,** 3, 357–370, Sept. 1953.

This paper gives an approximate method for computing main and interaction effects in two-way analysis of variance tables, where the number of observations in each cell is not the same (if they are the same, the analysis is available in standard texts on statistics). The method has the advantage of greatly reducing the time required to carry out the analysis by the more exact procedure due to Stevens [*Biometrika* **35,** p. 346, 1948]. The method of the author is useful in exploratory work on large masses of data, since it quickly gives some idea of the likely magnitude of the effects. For many purposes this approximate procedure will be adequate, although there will be borderline cases where one will want to use the more exact and time-consuming procedures.

B. Epstein, USA

683. Bacon, R. H., The "best" straight line among the points, *Amer. J. Phys.* **21,** 6, 428–446, Sept. 1953.

This review of the procedures for fitting a straight line to a group of points, using least-squares criteria of goodness, is more comprehensive than the usual presentations. It includes the

minimization of the ordinate residuals, which is the common procedure. It also includes the minimization of residuals in the abscissas and in both abscissas and ordinates. These methods are rarely shown and, in reviewer's opinion, rarely useful. Some rules are suggested for the evaluation of the adequacy of the fit and of the consistency of successive experiments. Pertinent statistical information is presented in an appendix.

R. Drenick, USA

684. Luke, Y. L., and Ufford, Dolores, A table of the complete Cicala function, *J. aero. Sci.* **20,** 7, 511–512. July 1953.

Note in Readers' Forum.

685. Lindley, D. V., and Miller, J. C. P., Cambridge elementary statistical tables, New York, Cambridge Univ. Press, 1953, 35 pp. $1.

Volume gives in a handy and compact form the more common and elementary statistical tables. Collection is convenient for applied worker and for study and teaching of statistics. Tract includes normal distribution functions, percentage points for normal, t, X^2, and F distribution, random sampling numbers, squares, square roots, reciprocals, logs, and others.

Y. Luke, USA

686. Fletcher, H. J., and Thorne, C. J., Sine and cosine transforms, *Studies appl. Math., Univ. of Utah* no. 8, 44 pp., Oct. 1952.

Report is a collection of title transforms. It extends existing tables. Methods for doing this are presented and techniques are applicable for further extension of present tables. Tables are useful in study of boundary-value problems where solution is obtained as a Fourier series. For applications of tables, see, e.g., AMR **4,** 3837; AMR **6,** 807. Y. Luke, USA

687. Bose, B. N., On certain integrals involving hypergeometric functions, *Bull. Calcutta math. Soc.* **44,** 4, 169–171, Dec. 1952.

Using the method of changing the order of integration, Barnes' method of evaluating contour integrals, and the principles of operational calculus, author obtains a number of infinite integrals involving ${}_1F_2\,(a;\ b;\ c;\ -z)$ and ${}_1F_1\,(a;\ b;\ -z)$. Well-known infinite integrals involving Bessel functions are then obtained as particular cases of the more general infinite integrals of the hypergeometric functions. The inversion of integrals is justified.

E. J. Scott, USA

688. Golubev, V. V., Lectures on integrating equations of motion of a rigid body about a fixed point [Lektsiĭ po integrirovaniyu uraveniye dvizheniya tjazhelogo tela okolo nepodvizhnoi tochki], Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1953, 287 pp.

An excellent textbook for the Russian universities and, in reality, a continuation of author's "Lectures on analytical theory of differential equations" [AMR **6,** Rev. 2972]. It applies theory of analytic functions and of differential equations to famous classical problem on motion of a rigid body about a fixed point.

The book has 8 chapters. The first of them deduces equations of motion, gives their first integrals, and shows the role of integral invariants in solving differential equations. Second chapter gives mathematical formulation of the well-known problem of S. V. Kovalevski and derives, by method of small parameter, basic results about this question. Third main part reduces the two fundamental cases, namely Euler-Poinsot's and Lagrange-Poisson's motion of a rigid body, to usual quadratures. In the fourth chapter the same is done for the case of Kovalevski.

Then come two sections containing special mathematical facts on algebraic functions, about elliptic and hyperelliptic integrals and their inversion. Seventh main part applies preceding theoretical results to general solution of the Kovalevski case and to some special related questions. The last chapter deals with the well-known solvable cases of Hesse-Appelrot, Goryachev-Chaplígin, and Bobilev-Steklov.

Book uses exclusively analytical methods. It is an extensive, well-written, and carefully composed textbook which can be highly recommended to engineers, physicists, and mathematicians. V. Vodička, Czechoslovakia

689. Weissinger, J., Contribution to the theory and application of the method of iteration (in German), *Math. Nachr.* 8, 193–212, 1952.

Applying theory of metric spaces, author gives an exact and elegant foundation of the method of successive approximations and shows its use in pure and applied mathematics.

The method in question is based on the fundamental theorem of fixed point (Fixpunktsatz), derived in §1. Author's general formulation should probably be considered as quite an original one. Following sections are devoted to various applications. First of all come sets of linear algebraic equations and some important facts from the theory of matrix equations. Third section deals with Fredholm's integral equations; §4 treats, by means of H. A. Schwarz's method, the first boundary-value problem of the theory of potential.

The next three paragraphs deal with nonlinear problems: §5 has for its subject sets of nonlinear equations; then comes the fundamental theorem on implicit functions, and §7 treats ordinary differential equations.

Mathematical value of the article consists, first, in that it gives a perfectly correct base to one of the most important methods of analysis and, secondly, in that it shows its various uses. Engineers' attention is called especially to §§3, 4, and 7.

V. Vodička, Czechoslovakia

690. Jung, H., An application of the Fourier transform to statics of plates (in German), *Math. Nachr.* **6,** 343–354, 1952.

In textbooks on elasticity, statical problems of the theory of rectangular plates are treated, as a rule, by the well-known classical methods of Navier and M. Levy, based on infinite series. Author shows how, for many important cases, the same can be done by means of the Fourier transform. In the case of $f\,(x,\ y)$, it is given by the relations

$$F(\lambda,\ y) = {}_{-\infty}\int^{\infty} f(x,\ y)e^{i\lambda x}dx$$

$$f(x,\ y) = (1/2\pi){}_{-\infty}\int^{\infty} F(\lambda,\ y)e^{-i\lambda x}d\lambda$$

and transforms the given differential problem (that is, equation with conditions on the boundary) in a solvable form. The procedure is analogous to the application of the Laplace transform.

Paper contains a short theoretical introduction and three paragraphs of examples. It is the sort of literature much in favor in technical circles, attacking without cumbersome constructions and yet, quite correctly, straight to the kernel of the problem in question. It makes an engineer familiar with a very useful method for solving advanced problems of his practice. We gladly recommend this fine and instructive paper to technicians and physicists. V. Vodička, Czechoslovakia

691. Uvarenkov, I. M., and Maller, M. Z., Introduction to analysis (Vvedeniye v analiz), Moscow, Učpedgiz, 1951, 253 pp.

At technical schools little attention is paid, as a rule, to preparatory facts for infinitesimal calculus. This volume presents

theory of real numbers and fundamental concepts of function, limit, and continuity. It also gives a short account of elementary functions. V. Vodička, Czechoslovakia

692. Natanson, I. P., Theory of functions of a real variable [Teoria funktsiĭ veschestvennoi peremennoi], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 399 pp.

Questions such as Lebesgue integrals, quadratic summability of functions, role of singular integrals in the theory of Fourier series, absolute continuity of functions, and others, become more and more significant in problems of modern engineering and mathematical physics. This excellent textbook by the well-known specialist is one of few convenient books where an engineer can readily learn these mathematical facts. Being intended for Russian high schools, the work gives to technicians, nevertheless, in its 17 chapters, all that is necessary in a correct and vivid presentation.

First three sections contain a short introduction to theory of sets (including fundamental concept of measure); then come four chapters on measurable functions, on Lebesgue's integral of a bounded function, and on the Lebesgue summability. The eighth main part treats functions with finite variation, explains the concept of Stieltjes' integral and of linear functional. Then follows a chapter on absolute continuity and on indefinite integral of Lebesgue, while the tenth section deals with singular integrals and trigonometric series.

The next three main parts concern point sets in two-dimensional spaces, with integration of measurable functions of many variables and with the role of set functions in the generalized theories of integration. Next two sections are of special character, dealing with the theory of transfinite numbers and with the classification of Baire. Of importance is chapter 17 containing many useful facts on abstract spaces. The last section shows contribution of Russian savants to the theory of functions of real variables.

The book is, without doubt, one of the best of its kind. It is warmly recommended to mathematicians and engineers.

V. Vodička, Czechoslovakia

693. Akhiezer, N. I., Elements of the theory of elliptic functions [Elementí teorii ellipticheskikh funktsiĭ], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1948, 291 pp.

Reading of this book presupposes fundamentals of analysis of a real and complex variable. The work is divided into 10 chapters and two appendixes, but only sections I, III–VI are of immediate importance for technical applications. Chapters VIII and X contain considerable advanced facts.

First section is introductory in nature, explaining fundamental concepts and definitions (periods of single-valued analytic functions, Weierstrass p-transcendents, theta functions, etc.). Third chapter presents a brief theory of elliptic integrals and of Weierstrass functions. Sections IV–VI contain a more detailed treatise of the theta and elliptic functions.

Of technical importance is section VIII, explaining the role of elliptic functions in conformal mapping. Reader's attention is called especially to chapter X containing many facts of applied mathematics.

There are numerous fundamental problems in techniques which require good knowledge of the subject in question, such as theory of pendulum, elliptic filters, many questions about motion of a solid with only one fixed point, important facts of the theory of girders, etc. As for more advanced problems, we mention at least the idea of elliptic coordinates and the Lamé equation.

Akhiezer's book informs about all these facts. In a clear and vivid presentation, without cumbersome constructions and superfluous theory, it directly attacks the kernel of the subject. Engineers and physicists will find this fine work well worth reading. V. Vodička, Czechoslovakia

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 672, 673, 688, 709)

694. Biezeno, C. B., and Grammel, R., Technical dynamics. I. Fundamentals and individual machine parts. II. Steam turbines and internal combustion engines. 2nd ed. [Technische Dynamik. I. Grundlagen und Einzelne Maschinenteil; II. Dampfturbinen und Brennkraftmaschinen], Berlin, Springer-Verlag, 1953, xii + 699 pp., 413 figs.; viii + 452 pp., 315 figs. DM 66; DM 44.

The first edition of this ambitious work is so well known that this review of the second, revised and enlarged edition can be restricted to a description of the added material. This concerns the following topics: A nonlinear elastic stress-strain law for small strains (8 pp.), methods of bounding the lowest eigenvalue (4 pp.), relaxation methods (16 pp.), wire strain gages (5 pp.), the determination of the bending moments at the supports of a continuous beam on elastic supports (3 pp. and separate computation forms), elastic half plane under arbitrary surface tractions (6 pp.), infinite elastic plane with one or two circular holes (13 pp.), more detailed formulas for the cylindrical shell under arbitrary loading (2 pp.), cylindrical shell with ring stiffeners (8 pp.), some remarkable instances of elastic instability of shafts, rods, and beams (6 pp.), theory and application of the pendulum damper (7 pp.).

In the new edition, the work has been divided into two volumes. The first of these comprises chapters I through VII and treats the foundations of the theory of elastic solids and its application to the analysis of typical structural members and machine elements. The second volume contains chapters VIII through XIII and is concerned with various mechanical problems encountered in the design of steam turbines and internal-combustion engines. All users of the unwieldy one-volume edition will welcome this division into two volumes. While the printing is excellent, it is to be regretted that the paper and binding are not of a quality consistent with the frequent use to which a work of this encyclopedic nature is likely to be subjected.

W. Prager, USA

695. Pérès, J., General mechanics [Mécanique générale], Paris, Masson et Cie, 1953, iv + 407 pp. 2110 Fr.

In this book the traditional content of a French course on mechanics is presented in a compact style of writing (which sacrifices no clarity) with compact notation and great attention to detail. Vectors are used, indicated by a superposed bar. Much useless writing is saved by the concept of a torseur, written $[T]$, this being a system of sliding vectors, two torseurs being equal if their vector sums and moments are equal. Thus the fundamental law of mechanics (used in this form systematically throughout the book) reads $[A_a] = [F_e]$, the first term being the torseur of quantities of acceleration (the vectors mass $\times$ acceleration for the particles forming the system), and the second the torseur of external forces. The subscript a indicates an absolute frame of reference; moving frames (which are treated extensively) are taken care of by adding to $[F_e]$ the torseur of fictitious forces.

The first three chapters cover principles, mechanics of perfect solids (rigid bodies), virtual work, and the theorem of energy. The author employs right-handed axes and the usual definition of a positive rotation; to the reviewer it seems a pity that he adheres to force vive and force function instead of using kinetic and potential energies, which terms are mentioned but not much

employed in the book. Chap. IV is devoted to the differential equation $(dq/dt)^2 = F(q)$ which occurs so often in mechanics. Chaps. V and VI deal with problems in the motion of a particle and a rigid body, including Foucault's pendulum and gyroscopic effects. Chap. VII gives Lagrange's equations and Appell's; it is indicative of the nature of the book that the integral of energy drops out as a particular case of Painlevé's integral, valid when T is quadratic but not homogeneous in the velocities. Chap. VIII deals with variational principles and Hamilton's equations; it includes an extremely neat transition from Hamilton's principle to the principle of least work. The last three chapters deal with small oscillations (with discussion of gyroscopic stabilization), impulsive motion, and the mechanics of continuous bodies, including the dynamics of strings and the propagation of discontinuities along them.

In the opinion of the reviewer, this is probably the most useful book available in this traditional field of mechanics, particularly for the reader interested in the mathematical structure of the subject. It is clearly written and easy to read, but the amount of detail covered is surprising in a single volume. Particular problems are worked out; there are no exercises for the student. In addition to a full table of contents, there is a short index—the reviewer would prefer it longer. There are some misprints in addition to those noted on an errata slip, but none likely to cause confusion. J. L. Synge, Ireland

696. Zyczkowski, M., Increased accuracy in calculating the piston motion in a simple crank system (in Polish), *Przeglad Mech.* **12**, 1, 21–25, Jan. 1953.

The calculations of the displacement, velocity, and acceleration of the piston in a simple crank system are troublesome. The author, analyzing the faults resulting from the usual simplified methods and criticizing Tolly's parabolic formula which expresses the acceleration of the piston, proposes to increase the accuracy of the calculations by applying series formulas for the displacement, velocity, and acceleration of the piston, taking into consideration a number of terms depending upon the demanded accuracy. To simplify the calculations of the acceleration of the piston $\ddot{x} = bR\omega^2$, $b = f(\lambda, \rho)$, author gives a table of values of the coefficient b depending upon λ and ρ, where λ is the ratio of the crank radius R to the connecting rod length L, and ρ is the ratio of the instantaneous displacement of the piston to its stroke $2R$ (ω constant angular speed of the crank). Author, applying the method to the "M20" motor, has shown that, with little difficulty, one can obtain great accuracy by calculating, in the example, the acceleration of the piston $\ddot{x}$ in the half of its stroke ($x = R$) and the position of the piston x_0 corresponding to a zero value for the acceleration. K. Wolski, Poland

697. Mertsalov, N. I.,, The theory of spatial mechanisms [Teoria prostranstvenníkh mekhanizmov], Moscow, Gosud. Nauch.-Tekh. Izdat. Mashinostroit. Lit., 1951, 205 pp. (pp. 3–124, 195–199). 11.40 rubles.

The title of this book is misleading. In reality, the book is a posthumous collection of nine of Mertsalov's papers of which the six first ones (124 pp.) deal with mechanisms, while three (76 pp.) do not. Moreover, the part dealing with mechanisms is partly concerned with plane kinematics or quite elementary theorems of spatial kinematics. Papers 7 and 8 (pp. 125–194) concern the hydrodynamic theory of lubrication and are reviewed separately [see Rev. 983 in this issue].

The first paper (12 pp.) deals with the determination of the position of a skew seven-bar linkage by means of descriptive geometry. The second is a three-page remark on the velocity distribution in a seven-bar chain. The third paper (56 pp.) is mostly expository and has been compiled from the author's 1920–1921 lectures on space kinematics by one of his students. It contains some further remarks about seven-bar space linkages. Papers four and five (46 pp.) treat gears with skew axes and are mostly expository. Paper six (6 pp.) suggests how to use a chain belt to produce a variable transmission ratio between two parallel axles (when unround gears are inconvenient).

The ninth paper (5 pp.) considers the motion of a rigid body with a fixed point at which $A = B = 4C$, the mass center being located in equatorial plane of the inertial ellipsoid. Author derives two equations for $\omega = (p^2 + q^2)^{1/2}$ and q, containing the energy constant and the constant vertical momentum component, from the energy equation and the vertical momentum equations. One of these equations is integrable again if $A = 4C$, and an equation for ω alone can be obtained. The approximate solution for q and ω by means of a two-term polynomial in $\zeta = \int pdt$ is given. [The dependence of ζ on t will have to be determined by another integration.] A. W. Wundheiler, USA

698. Wilson-Jones, R. A., Steering and stability of single-track vehicles, *Instn. mech. Engrs. Auto. Div., Proc.*, part IV, 191–202, 1951–1952.

Paper gives first full practical consideration known to reviewer of steering stability of single-track vehicles, e.g., motorcycles, taking into account flexibility of tires and consequent slip angle and camber thrusts and torques. Discussion is qualitative and experimental rather than mathematical. Author claims that cycles are stable except at very low speeds owing to automatic turning toward direction of lean, principally due to trail of front wheel. Unlike automobiles, cycles steer principally owing to camber thrust, and slip angle thrust is relatively negligible. Paper is accompanied by discussion of equal length, some of which is extremely valuable. E. M'Ewen, England

699. Bayer-Helms, F., and Pick, H., The Coriolis force on a body submerged in a fluid (in German), *Z. Phys.* **134**, 5, 582–595, 1953.

A body of mass m moving with velocity v in a reference system rotating with angular velocity ω experiences Coriolis force $2m\omega \times v$. If the body is submerged, this force is diminished by Coriolis forces totaling $2M\omega \times v$ on the fluid elements in the eddy about the body, with M a virtual mass. Effective mass $m - M$ may be negative. Experimental curves of M for spheres of various sizes in different media plotted against speed show a rapid drop to a minimum and then a slow rise to an asymptotic value as the speed increases. The high virtual mass at low speeds agrees with a solution by G. I. Taylor (1917) of the Navier-Stokes equations which indicated a cylinder of fluid with axis parallel to the axis of rotation moving with the body causing large eddies in the most effective direction. At medium speeds, the cylinder collapses to give a drop in M. At high speeds, the body is effectively lengthened by its attached wake.

The experimental apparatus is simple, ingenious, and sensitive. C. M. Ablow, USA

700. Tsenov, I., New form of equations for analytical dynamics (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **89**, 1, 21–24, Mar. 1953.

Author presents a new form of dynamical equations

$$\lambda/2(\partial\ddot{T}/\partial\ddot{q}_i - 3\partial T/\partial q_i) = Q_i (i = \lambda, \ldots, S)$$

for holonomical systems movement. Deduction is simply made from fundamental one, $\Sigma(-m\ddot{M} + F)\delta M = 0$. A second equation $\partial K/\partial\ddot{q}_i = 0$ is derived after introduction of certain functions such as $T_0 = T$ for $T = \Sigma \frac{1}{2} mV^2$ when $\dot{q}_i$ are fixed; $R = \frac{1}{2}(\ddot{T} - 3T_0)$; and finally $K = R - Q_i\ddot{q}_i$.

Equations are extended to anholonomical systems and paper closes with reference to Euler's equations for rigid polar movement, which appear as a consequence of author's. Appel's energetic acceleration is recognized as inspiration source. Author also cites Dobronravov's papers, one about Euler's equations, and another dealing with Appel's Π_β equations.

Reviewer accepts originality and correctness of this theoretical paper. J. E. Carrizo Rueda, Argentina

701. **Kragelsky, I. V., and Ščedrov, V. S., Improvement of the performance of the traveler-ring system** (in German), *Faserforsch. u. Textiltech.* **4**, 5, 212–217, May 1953.

The aim of the authors is to deduce the optimum shape of the traveler of a ring-spinning frame from an analytical study of its motion. The traveler is considered as a body—and not as a point, as is usually assumed. Its oscillation in a meridian plane is studied; the tension of the yarn and the point of application of the tension are supposed to vary for each revolution, according to a sinusoidal function of time. The results are discussed. Among the conclusions deduced from the results, reviewer mentions: (1) The mass of the traveler should not be uniformly distributed; (2) the inner part should be heavier than the outer part in such a manner that the moment of inertia about the contact point of ring and traveler should have a relatively low value. Authors are aware that the realization of the proposed shape leads to some technological difficulties. They assure that tests made in a spinning mill showed the superiority of the proposed shape over the ordinary shape in regard to wear and endsdown.

D. De Meulemeester, Belgium

702. **Agostinelli, C., Equilibrium configurations of a homogeneous liquid mass attracted from distant centers in accordance with the Newtonian law** (in Italian), *Mem. Accad. Sci. Torino* (2) 71, part 1, 1–48, 1951.

First part of investigations on ellipsoidal configurations of a liquid, incompressible, nonviscous, homogeneous mass under the influence of mutual Newtonian attraction and of attraction from n distant points which are situated in the equatorial plane of the mass. The velocities of mass particles are given by a time-dependent linear vector function, and from general theorems of mechanics and hydrodynamics some basic equations for the movement and form parameters are obtained. The formula derived from the theorem of angular momentum is a generalization of earlier results obtained by Stekloff and Boggio under the assumption that there are no outside attraction centers. A special form of movement is assumed then, which can be decomposed in a rotation about the axis of the mass normal to its equatorial plane and in a dilatation with an axis in the same direction. The potential of external forces for a mass particle is determined by its position vector and by a scalar, a vector, and a dilatation, which are functions of the position of attraction centers only. If the ellipsoid axes coincide with those of the dilatation and if the centers of attraction are fixed, the external form and angular velocity of the ellipsoid remain constant. Two equations between the lengths of the ellipsoid axes and its angular velocity can then be derived, which form the basis for further considerations and which, in the absence of attraction centers, yield the well-known classic conditions for the existence of ellipsoids of Jacobi and Maclaurin.

In the second half of the paper, the two basic equations are examined in detail and the principal results are: The ellipsoid rotates about its shortest axis, and the two other axes are usually not of equal length. Under certain conditions, depending on the position of the attraction centers, four ellipsoid configurations of static equilibrium are possible, one of which is nearly spherical, the second is flat, and the two others have one transversal axis elongated. For other conditions, two configurations are possible where the speed of rotation ω tends to infinity and there is always a relative maximum of ω^2 which, in the absence of attraction centers, either corresponds to a configuration close to the critical rotation ellipsoid of Maclaurin or yields to the maximum value of ω^2 for ellipsoids of Jacobi.

In a subsequent paper, critical ellipsoids will be treated according to the method of Poincaré. A. Kuhelj, Yugoslavia

703. **Burwell, J. T., and Rabinowicz, E., The nature of the coefficient of friction,** *J. appl. Phys.* **24**, 2, 136–139, Feb. 1953.

The coefficient of friction between dry metal surfaces is defined as the ratio of shear strength to flow pressure in the contact area. These quantities are not constant for the flow surfaces—as earlier believed—and also, the coefficient of friction is not constant. This behavior is particularly marked when one material possesses considerable plasticity. It can be seen that, in this case, time plays an important part.

Experiments were therefore made in which the coefficient of friction is measured as a function of sliding velocity. Steel on indium and on lead was examined. It was found that the velocity decreases as the time of friction increases. Finally, a constant final sliding velocity is reached and this magnitude again depends upon the friction coefficient. The plot of friction coefficient against final sliding velocity shows a maximum, the rising branch of the curve being more pronounced than the descending branch. Here the mechanism of dry friction appears very clearly.

The friction force arises from minute local welds formed between the two bodies in contact, and through this characteristic the shear strength, the flow pressure, and the true contact area are altered. At low velocity, the welding energy developed per unit time is smaller than at high velocity. At very high velocities, the contact time is not large enough to permit developing the maximum welding energy per unit area and, because of the irregularity of the true areas, the sliding becomes unstable.

P.-P. Heusinger, Germany

704. **Thomsen, J. S., Coulomb friction with several blocks,** *Amer. J. Phys.* **21**, 6, 446–452, Sept. 1953.

An exhaustive numerical and graphical discussion is given for the following problem: One block lies on the ground, another block lies on top of the first one. What are the initial accelerations of each block under the action of two external forces if, between the two blocks and between the lower block and the ground, Coulomb friction is assumed?

The generalization for an arbitrary number of blocks and forces is indicated. As a practical example, the blast loading of a multistory building is mentioned. H. L. Oestreicher, USA

705. **Bade, W. L., Relativistic rocket theory,** *Amer. J. Phys.* **21**, 4, 310–312, Apr. 1953.

Paper discusses integration of the equation of motion of a rocket in empty space for the one-dimensional relativistic case. The space coordinate X of the rocket and corresponding time T, measured in an inertial frame, are determined as parametric functions of the proper time s of the rocket. Ackeret's results for the differential equation of motion and the mass ratio are reproduced. It may be noted that the restriction of the exhaust velocity $-w$ to a constant value relative to the rocket actually is needed only in Eqs. (7) and (8). J. J. Gilvarry, USA

706. **Tsien, H. S., Take-off from satellite orbit,** *J. Amer. Rocket Soc.* **23**, 4, 233–236, July-Aug. 1953.

The mass ratio or the characteristic velocity for the take-off

of a space ship from the satellite orbit is computed for two cases: the radial thrust, and the circumferential thrust. The circumferential thrust is much more efficient in that the required mass ratio is much less than for the radial thrust. Both cases show, however, an increase of the required mass ratio and the characteristic velocity with a reduction in acceleration. With circumferential thrust, the characteristic velocity increases by a factor of two, when the acceleration is reduced from $^1/_2$ g to $^1/_{3000}$ g.

From author's summary

Gyroscopics, Governors, Servos

707. Long, M. V., and Holzmann, E. G., Approaching the control problem of the automatic chemical or petroleum plant, *Trans. ASME* **75,** 7, 1373–1381, Oct. 1953.

Paper illustrates application of frequency-response techniques to two specific process-control problems. In second problem, dealing with a pneumatic speed-control system, the stability determination entails experimental measurements of dynamic characteristics of various elements in control chain. To avoid serious nonlinearities, small signal amplitudes are used. It is nevertheless implied that this is only a limitation of the experimental technique and that satisfactory use may be made of these results.

It is stated that process control will make increasingly greater use of computing elements to obtain almost complete automaticity, but human operator will still exercise supervision.

Reviewer believes that analytic techniques used in other control fields should certainly be used in process controls, but disagrees completely with reasoning in second problem. It is a mathematical fact that transfer functions obtained from measurements with inputs sufficiently small to avoid an appreciable nonlinearity cannot generally be extended to larger inputs or disturbances and, in fact, such extension would have no meaning. Consequently, such stability determination would be valid for only sufficiently small inputs and would be of little practical use.

L. Becker, USA

708. Davis, S., Rotating components for automatic control, *Prod. Engng.* **24,** 11, 129–160, Nov. 1953.

Paper gives informative and concise survey of electrical and mechanical characteristics of some commonly used components of automatic control systems. The illustrations are particularly worth while.

L. Becker, USA

709. Bauer, B. B., Transformer couplings for equivalent network synthesis, *J. acoust. Soc. Amer.* **25,** 5, 837–840, Sept. 1953.

Paper represents a contribution toward the development of a rational basis for constructing and understanding electromechanical analogies—a subject that has occupied the attention of several writers during the past two decades. The main feature of the paper is an emphasis on understanding and appreciating the central role played by the ideal coupler concept in the formulation of analogies. In this respect, the author extends his material given in a previous paper [title source **23,** p. 680, 1951].

An ideal coupler may be defined as a device which is capable of transmitting energy but neither absorbs nor stores it, which properties are obtained by the imposition of constraints between dynamical variables. Typical examples are: the ideal lever, the workless constraints of Lagrangian mechanics, and the ideal transformer in electric network theory. An ideal coupler represents the most general type of constraint; all other constraints, such as actual physical connections, can be shown to be dynamically (but not topologically) equivalent to a set of ideal couplers. Hence the author is able to show that the electric analog of any mechanical system can be constructed by displaying the analog of each part of the original system separately, representing the constraints of the connected system by ideal couplers, and then by removing most if not all of the couplers by the use of three network rules. This process is straightforward and always yields a dynamically valid analogy. What the author does not point out is that this process can suppress physical information, particularly information about reference points.

This last point shows that, although the author has made an important contribution to the subject, some problems still require consideration. In reviewer's opinion, the subject will not be fully developed until an isomorphism is fully defined between the parent system and its analog, for surely the subject of analogies can, at most, be some sort of an isomorphism. This lack of a clearly defined isomorphism leads the reviewer to differ in one respect with the author. He states, in effect, that an electric analog of a mechanical system made up of mass points shows a "debility" if the analog is based upon the force-voltage isomorphism, and a similar debility appears for fluid systems if a velocity-voltage isomorphism is used. However, author does not define what he means by a debility; supposedly it is something that an investigator senses intuitively. Reviewer suggests that if an isomorphism is carefully defined, the term debility then may not be applicable to the fluid case where the author thinks it does apply.

H. M. Trent, USA

710. Grammel, R., The steady motions of the self-excited gyroscope and its stability (in German), *Ing.-Arch.* **21,** 3, 149–156, 1953.

The body is pivoted at a fixed point O. The coordinate system is fixed in the body; the principal axes of inertia for O are coordinate axes x, y, z. A self-excited gyroscope has about O a nonzero moment vector of external forces, with constant components M_x, M_y, M_z. A permanent rotation has a vector of angular velocity, with constant components ω_x, ω_y, ω_z.

By means of Euler's equations, author studies solutions which give permanent rotations. The gyro being symmetrical, there is a ∞^3 family of permanent rotations that are "almost all" stable. The gyro being nonsymmetrical, there is a ∞^3 family of permanent rotations that are "almost all" unstable.

Author clarifies apparent discrepancy between above conclusion and well-known results concerning Staude motions. It is true that Staude's moment vector of gravity about O is constant with respect to the body in the case of permanent Staude rotation; a disturbance, however, breaks down this constancy. Instability of permanent rotations can be avoided by making M_x, M_y, M_z not strictly constant but depending on ω_x, ω_y, ω_z. Paper finishes with the proof that, except for the permanent rotations studied, no stationary motions of a self-excited gyro are possible.

W. L. Esmeijer, Holland

711. Weber, H. E., Methods for calculation of automatic controls (in German), *ZAMP* **4,** 4, 233–260, 1953.

Based on the numerous publications dealing with feedback-control systems, the essential features of the phase-attenuation method most suitable for the design of regulators and servomechanisms are shown. Measures to increase stability, series and parallel compensation, influence of disturbances, transient behavior, and the effect of a finite time delay within the system are discussed. As an example, the transfer function of a d-c shunt motor is derived. The method is suitable for linear systems only; nonlinear systems may be analyzed by assuming small deviations from a steady-state value.

From author's summary

712. **Torielli, E., Comparison between hydraulic, pneumatic, and electric regulation devices** (in Italian), *Termotecnica* 9, 9, 379–382, Sept. 1953.

The comparison briefly discusses automatic control systems from the following points of view: Capability to solve a given problem of control, simplicity, precision, safe operation of components, quick response, maintenance with special respect to avoid manual control during maintenance operations, and from the point of view of costs. H. Bückner, USA

713. **Chu, Y., and Gould, L. A., Analogies for hydraulic and electric drives in servomechanisms,** *Trans. ASME* **75,** 6, 851–857, July 1953.

See AMR 6, Rev. 2435.

714. **Dommasch, D. O., The relation between open-loop stability and frequency response diagrams for linear systems,** *J. aero. Sci.* **20,** 7, 506–509, July 1953.

Note in Readers' Forum.

715. **Blackburn, J. F., Contributions to hydraulic control,** 3, 4, 5, *Trans. ASME* **75,** 6, 1163–1169, 1171–1173, 1175–1180, Aug. 1953.

See AMR 6, Revs. 2820, 2337, 3278.

Vibrations, Balancing

(See also Revs. 672, 724, 808)

716. **Baillard, G., On the dynamics of springs. General exact solution of the equation of vibrating strings as applied to gun mounts** (in French), *Mem. Artill. fr.* **27,** 1, 77–95, 1953.

Author investigates the behavior of springs used in recoil mechanisms and shows that this problem reduces to the equation of a vibrating string in the case when a mass is fastened at one end of the string and when the latter has a distributed mass corresponding to that of the coils of the spring. The characteristics of the wave equation are given for one interval corresponding to the passage of the wave from one end of the spring to the other, and a recurrence relation is established by which the effect of the subsequent reflections of the wave is taken into account. The establishment of this recurrence relation occupies the major part of the paper and cannot be abstracted here. It is sufficient to indicate the final conclusion, namely, if the initial stress is zero, the solution of the wave equation is given in terms of an absolutely convergent series whose limit gives the dynamic correction to be added to the static stress. This permits calculating the work absorbed in a mechanism of this kind.

N. Minorsky, France

717. **Kornhauser, E. T., and Mintzer, D., On the vibration of mass-loaded membranes,** *J. acoust. Soc. Amer.* **25,** 5, 903–906, Sept. 1953.

The conventional treatment of a vibrating membrane with a small mass load, originated by Rayleigh, leads to perturbed eigenfrequencies slightly lower than the unperturbed values and independent of the area of the load so long as it is small compared to the area of the membrane. It is shown that this result is incorrect because of an invalid initial assumption about the amplitude of vibration of the load. Actually, the perturbed frequencies are slightly higher than the unperturbed values, depend upon the area of the load, and approach the unperturbed values as the load approaches a point mass. In addition, a very low frequency mode exists whose frequency approaches zero as the load becomes smaller in area; this mode represents a perturbation of the trivial zero-frequency solution in the unperturbed case. The special case of a circular membrane loaded at the center is discussed in some detail.

From authors' summary by D. Williams, England

718. **Mettler, E., Nonlinear vibration of elastic bodies** (French and German), *Publ. sci. tech. Min. Air, Paris* no. 281, 77–96, 1953.

Clear exposition of researches of author and others on the oscillations of elastic bodies in which the deformations are not regarded as infinitesimal. D. Graffi, Italy

719. **Ledinegg, E., and Urban, P., Contribution to the theory of vibration of isotropic elastic bodies** (in German), *Acta Phys. Austr.* **7,** 4, 420–435, Sept. 1953.

The eigenvalue problem of a vibrating inhomogeneous isotropic body is solved by considering the small deviations from homogeneity as a perturbation term. It is found that the change of each natural frequency, compared with that of the homogeneous body, is proportional to the change of total deformation energy due to variations of the elasticity moduli and of the medium density. The result is readily generalized to calculate the change of natural frequency in a hollow acoustic resonator due to deformation of boundary surface.

Examples are given for coaxial cylinders of different materials, either placed one in another or end to end. By allowing one of the cylinders to become infinitely large, the cases become a rod or a plate placed in a fluid-filled resonator.

L. S. Dzung, Switzerland

720. **Draminsky, P., Subharmonics in torsional crankshaft vibrations and some general remarks about subharmonics in nonlinear systems** (French and English), *Publ. sci. tech. Min. Air, Paris* no. 281, 129–157, 1953.

Subharmonic vibrations in single-degree-of-freedom systems are discussed. Linear systems with periodically varying stiffness and nonlinear systems of the Duffing type are considered. Criteria are given for the existence of subharmonics of order $1/2$ or $1/3$, whichever is applicable for the particular case treated. Method used involves the well-known application of truncated Fourier series to the representation of appropriate steady-state solutions. Choice of particular form of solution is guided by physical reasoning. Criteria presented indicate, in general, only a remote possibility that subharmonics will be excited in the very simple systems considered; but they are valuable as a simple rough check for design purposes where one-degree-of-freedom approximations are valid.

Reviewer believes the primary engineering value of this paper derives from the emphasis given to a somewhat neglected area in vibration analysis rather than from the over-all utility of the present results. R. B. Grant, USA

721. **Ziegler, H., Critical frequencies under the influence of torsion and axial loads** (in German), *Ing.-Arch.* **20,** 6, 377–390, 1952.

Author presents a careful re-examination of the whirling-shaft problem. Effect of torsional load on critical speed is shown to depend on whether axis of torsional moment remains parallel to undeflected shaft or not. In latter case, a single couple of parallel forces, which ride with shaft (quasitangential moment) and a set of two or more uniformly distributed couples of the same type (semitangential moment) are investigated and shown to have different critical speeds. Three particular mountings of a

single disk are studied. Effects of axial loading and gyroscopic forces are also included. Method of analysis consists of careful study of the complete dynamic equations for unsteady motion. This is called the kinetic method in contrast to the usual static method in which a state of indifferent equilibrium in a deflected position is assumed. S. H. Crandall, USA

722. McLachlan, N. W., Theory of vibrations, New York, Dover Publications, Inc., 1951, vi + 154 pp. $1.25.

Dr. McLachlan has written a number of well-known textbooks intended to present the student with analytical tools required in applied physics and, to an even larger degree, in modern engineering. The purpose of this latest addition to his texts on applied mathematics is to acquaint the first-term graduate student with the theory of vibrations. This brief treatise is almost purely theoretical, and might be described as the mathematical skeleton on which the individual lecturer can graft the illustrative example and practical applications of his own choice. The style is, as usual, lucid and the mathematical analysis concise and easy to follow. However, unless this book is closely synchronized with a first-term graduate course in applied mathematics, many students may be baffled by some fairly sophisticated mathematical methods.

The book covers the usual topics in mechanical vibrations (systems with a finite number of degrees of freedom, nonlinear systems, strings, bars, membranes, and plates). There is, however, one unusual feature in that one chapter deals with sound waves of finite amplitude and in that the fundamentals of one important electromechanical system are discussed. Ever since Lord Rayleigh, it has been customary for acousticians to dedicate the first half of their treatises on the theory of sound to the topic of mechanical vibrations. It is pleasing to see that this courtesy has at last been partially returned.

Much space and effort are saved in the consistent application of operational methods to the analysis of forced vibrations. It is, however, regrettable that a text such as this should not give any example of the use of elementary variational methods and should not mention such powerful and useful concepts as generalized forces and coordinates and Lagrange equations. In spite of these lacunae, it is remarkable that the author should have lucidly presented such a vast amount of information in such a short space. Also, in these days where scientific textbooks costing less than $5.00 have become a distant memory from the reviewer's undergraduate days, it is just as much of a tour de force that the publisher should have made available this material for the modest price of a student's dinner. The introduction of paperbound textbooks, which are standard in Latin countries, certainly seems like an excellent idea. M. C. Junger, USA

Wave Motion, Impact

(See also Revs. 672, 987)

723. Thorne, R. C., Multipole expansions in the theory of surface waves, *Proc. Camb. phil. Soc.* **49,** part 4, 707–716, Oct. 1953.

Linearized wave motion caused by line and point singularities in shallow and deep nonviscous incompressible fluid with a free upper surface is investigated, the motion being taken to be simple harmonic in time. To insure uniqueness, the well-known condition that the motion at infinity should be that of a diverging wave is imposed. In the two-dimensional problem for deep or shallow fluid, the velocity potential is obtained for symmetric oscillations, antisymmetric oscillation, and logarithmic singularity. In the three-dimensional problem for deep or shallow fluid, the velocity potential is obtained for a point singularity.

J. K. Lunde, Norway

724. Lee, E. H., and Kanter, I., Wave propagation in finite rods of viscoelastic material, *J. appl. Phys.* **24,** 9, 1115–1122, Sept. 1953.

Paper deals with the propagation of pulses of one-dimensional extensional waves in a linear Maxwell solid, which can be represented, in the form of a model, by a spring and dashpot in series. The pulse solution for a Voigt solid (spring and dashpot in parallel) was discussed, as a special case, by Thomson [*Phil. Trans. roy. Soc. Lond.* (A), **231,** 339–407, 1933], and Charles [AMR **4,** Rev. 4392] has more recently given a pulse solution for a material possessing hereditary properties. In addition, Malvern [AMR **4,** Rev. 2372] has treated a general case, which includes the linear Maxwell solid as a special case, by the method of characteristics.

In the present paper, the one-dimensional equation of wave propagation in a linear Maxwell solid is shown to be analogous to the telegraph equation, and solutions are first obtained, by using Laplace transforms, for the case of a rod extending from $x = 0$ to $x = \infty$, when the end $x = 0$ begins to move with constant velocity at time $t = 0$. The results are expressed in terms of nondimensional variables, and it is shown that the front of the disturbance, which is sharp, travels with the velocity of elastic waves in the solid and that the magnitude of the discontinuity of stress at the pulse front decays exponentially with x. By means of a method of images, the treatment is extended to rods of finite length l and examples are given of the variation of stress with x for rods in which the end $x = l$ is (a) free, (b) fixed. The paper concludes with a general discussion in which it is shown that the main feature of the phenomena is determined by the relative magnitudes of (a) t, (b) the relaxation time, and (c) the time taken by the elastic wave to traverse the length of the specimen.

R. M. Davies, Wales

725. Sretenskiĭ, L. N., Spatial problem for the determination of steady waves of finite amplitude (in Russian), *Doklady Akad. Nauk. SSSR (N.S.)* **89,** 1, 25–28, 1953.

Making use of the wave potential in the form $\varphi(x, y, z) = -vx + (\alpha_{11}e^{k_{11}z}\cos ny + a_{13}e^{k_{13}z}\cos 3ny + \ldots)\sin mx + (\alpha_{20}e^{2k_{20}z} + a_{22}e^{2k_{22}z}\cos 2ny + \ldots)\sin 2mx + \ldots$ and of a small parameter ϵ, each coefficient α_{ns} is expanded in a power series. The factors v, m, n are assumed to be given numbers and the substitution $\tau = qt$, $v = q\nu$, $\alpha_{11} = q\epsilon$ is used. The conditions for all these unknowns are obtained if one integrates the equations of motion by expanding the coordinates x, y, z in power series in ϵ and takes into account the Bernoulli integral.

W. S. Jardetsky, USA

726. Maue, A.-W., Diffraction of elastic waves on the semi-plane (in German), *ZAMM* **33,** 1/2, 1–10, Jan./Feb. 1953.

In contrast to the corresponding optical case, reflection of elastic waves at the free surface of an elastic half space leads, according to Kelvin, to two reflected waves, a longitudinal and a transverse one. Refraction at a semi-infinite plane in a half space has been treated by Sommerfeld for electromagnetic waves; the obstacle in applying his method to the elastic case lies in the fact that two boundary conditions, instead of one, must be satisfied at the refracting screen; the normal and the shear stresses must vanish. The method used here, originally developed by Clemmow and Hönl, represents the solution by superposition of plane waves with the spectral distribution of the amplitude as unknown function. The resulting system of linear integral

equations is reduced to the problem of splitting a complex function into two factors in such a way that each factor contains a prescribed portion of the singular points of the function; this is achieved by means of Cauchy's theorem.

There are no numerical results. W. Freiberger, Australia

Elasticity Theory

(See also Revs. 690, 726, 739, 765, 779, 786, 823, 936)

727. **Colonnetti, G., Generalized expression of theory of reciprocity** (in French), *C. R. Acad. Sci. Paris* **237,** 12, 589–591, Sept. 1953.

The reciprocal theorem has been extended to the case when an elastic body possesses thermal, plastic, or any other type of strain coexistent with the elastic deformation produced by applied forces. S. C. Das, India

728. **Capriz, G., Application of partial Laplace transform with finite integration interval to a two-dimensional elasticity problem** (in Italian), *Ann. Scu. norm. sup. Pisa* (III) **7,** I–II, 17–41, Jan.–June 1953.

Author first describes A. Ghizzetti's method which uses Laplace transform with finite interval. Author's application is based on this but actually uses Fourier transform with infinite interval. He begins with the two equations of equilibrium for plane stress expressed in terms of displacement components. Considering infinite strip $0 \leq x \leq 1$, Fourier transform with respect to y is performed. With restriction that displacements are zero along $x = 0$ and $x = 1$, solution of transformed equations is expressed in form of Green's function integrals. Inverse transform then represents desired solution of displacements under action of body forces. Paper concerns formal mathematics of the problem and does not touch on question of working out solutions of specific problems. G. W. Housner, USA

729. **Shevchenko, K., Plane problem for an infinite elastic medium weakened by a circular, cylindrical area** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **89,** 5, 799–800, Apr. 1953.

Under the hypotheses that in the cylindrical area two equal and opposite forces p act, and that at infinity the stresses equal δ_0 in all directions, author solves this problem under the condition that the boundary of area is not stressed.

Using bipolar coordinates α, β, he gives the fundamental equations of the plane theory of elasticity. Assuming that the stresses $\delta\alpha$, $\delta\beta$ outside of this area depend on the integral functions $\varphi(\beta)$, because of the symmetry and boundary conditions at infinity there is obtained $\varphi(\beta) = -2\delta_0 \sin \beta$. The stresses are $\delta\alpha = \delta_0(2\mathrm{Ch}\alpha - \cos\beta)\cos\beta$; $\delta\beta = \delta_0 \cos^2\beta$. Between p and δ_0 the relation is $p = \delta_0\pi$. [See AMR **5,** Rev. 2038.] D. Rašković, Yugoslavia

730. **Mindlin, R. D., and Deresiewicz, H., Elastic spheres in contact under varying oblique forces,** *J. appl. Mech.* **20,** 3, 327–344, Sept. 1953.

An investigation is made of the phenomena occurring at the contact surfaces of like elastic spheres subjected to a variety of applied forces. Owing to the presence of (frictional) slip, with its associated energy dissipation and permanent set, the changes in tractions and displacements depend not only upon the initial state of loading, but upon the entire past history of loading and the instantaneous relative rates of change of the normal and tangential forces. On the basis of three of the simplest cases of varying oblique forces, a set of rules of procedure is assembled and then applied to two types of problems. In the first, the initial tangential compliances are calculated for a variety of past histories and instantaneous rates of loading; in the other, a detailed history of a varying oblique force is investigated. Extensive graphical representation of results is employed to supplement the analytical work.

From authors' summary by D. C. Drucker, USA

731. **Dzhanelidze, G. Yu., General solutions of equations for the theory of elasticity in arbitrary curvilinear coordinates** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **88,** 3, 423–425, Jan. 1953.

Assuming that the displacement vector can be derived from four harmonic functions, author computes strains and stresses in general coordinates according to Hooke's law. The boundary-value problem is not considered. F. I. Niordson, Sweden

732. **Kumar, S., and Joga Rao, C. V., Investigation of stresses around a hole in thin rotating disks of hyperbolic and parabolic profiles,** *J. Indian Inst. Sci.* **35,** 2, 93–102, Apr. 1953.

Of the investigated disks, the law of thickness distribution is given by $h = Cr^n (r_0 \geqslant r \geqslant r_i)$. The stress concentration on the edge of the hole ($r = r_i$) is determined as a function of n. The function appears to be monotonic increasing with n, besides a singularity for $n = 8/3 + \nu$ (ν = Poisson's ratio).

In reviewer's opinion, there is no singularity. It is introduced by taking a wrong particular integral of the differential equation for $n = 8/3 + \nu$. This integral should be $2(3 + \nu)C \log \tau / \{n_s^2 - 4rn_s + 4\}^{1/2}$; $n_s = 8/3 + \nu$, as can be shown by applying the method of variation of constants. J. W. Cohen, Holland

733. **Olszak, W., Initial stresses in anisotropic bodies** (in Polish), *Bull. Polish Acad. Sci. Lett., Suppl.* **1,** 47–60, 1952.

Paper is a continuation of author's previous research work (1936, 1946, 1948) on elastic stress problems of curvilinear anisotropic bodies, especially of his solution for cylindrical anisotropy [Sec. Congr. Polish Struct. Eng., Fin. Rep., 61–69, 1936]. He considers initial stresses in anisotropic bodies, e.g., shrinkage in cast iron, in concrete and reinforced concrete; thermal stresses are considered as a special case, etc. Author applies the principle of virtual work and considers the change of the total strain energy for appropriately chosen symmetric virtual displacements. Thermoelastic states are discussed, for thermal as well as elastic anisotropy. Finally, an example for determining the permanent set of shrinkage stresses in an anisotropic, brittle (e.g., concrete) cylinder is worked out, explaining cracks by tensile stress concentration at the outer surface.

T. Wojcicki, Poland

Experimental Stress Analysis

734. **Goodman, L. E., and Sutherland, J. G., Application of silver chloride in investigations of elasto-plastic states of stress,** *NACA TN* 3043, 55 pp., Nov. 1953.

Stress-optic relationships in silver chloride crystals were investigated. The law was determined from single crystals using a theory corresponding to that developed by Pockels. Experimental confirmation of a stress-dependent law was obtained. Bicrystals and polycrystals also were studied.

The stress-dependent optic law is explained on the basis of proportionality of relative retardation to crystal stress, whereas strain depends upon relative movements of crystal grains. Stress-concentration factors for holes and edge notches in rectangular strips were obtained and compared with the isotropic

counterpart, from which it was found that there is considerable difference between the two. This was done in both single-crystal and in polycrystal specimens. H. Becker, USA

735. Ôkubo, H., Determination of the surface stress by means of electroplating, *J. appl. Phys.* **24,** 9, 1130–1133, Sept. 1953.

Paper describes a new method of determining dynamic stress concentrations on the surface of parts subjected to cyclic loading. A thin copper layer on the surface of a test object, deposited by electroplating, has the property of changing color with a certain value of the applied strain. On static loading, the phenomenon is not very clear; on cyclic loading, however, the color deepens with increasing number of cycles. In this case, the strain value, above which the discoloring begins, seems to be very well deformed. A description of the method and recipes of the plating solution are presented. The stress concentration in a circumferential notch on a circular shaft under torsional loading is determined and compared with some theoretical solutions; the agreement is very good. R. G. Boiten, Holland

736. Curtis, A. J., and Richart, F. E., Jr., Photoelastic analogy for non-homogeneous foundations, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 211, 35 pp., July 1953.

Theory of stress distribution in a semi-infinite body having a constant value of Poisson's ratio and a modulus of elasticity E which varies with depth is reviewed. Analogy between stresses in a constrained slice with variable E and stresses in a plate whose thickness varies in the same manner as E in the constrained slice is developed. Stresses in plate of variable thickness subjected to an edge load in the plane of the plate are assumed to be two-dimensional and are determined by means of photoelasticity. Analogy thus gives stress distribution beneath an infinite line load on a foundation with a variable E. Details of photoelastic model are discussed and experimental results are compared with theoretical results. W. B. Stiles, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 681, 720, 721, 724, 771)

737. Rohde, F. V., Large deflections of a cantilever beam with uniformly distributed load, *Quart. appl. Math.* **11,** 3, 337–338, Oct. 1953.

The approximation of the elementary beam theory, that the curvature $1/R = d^2y/dx^2$, does not hold when deflections are large. The rigorous relationship ($1/R = d\theta/ds = M/EI$) (θ slope, s arc length) results, in this instance, in the two differential equations $dM/ds = -ws\cos\theta = EI(d^2\theta/ds^2)$. The author's approach is to expand θ in power-series form in terms of s and thereafter to equate coefficients of the s-terms of equal power. With the relationship between θ and s established, M is determined directly from $M/EI = d\theta/ds$ and the deflection y is found from $dy/ds = \sin\theta$ by integration of the power-series expansion of $\sin\theta$. When making the appropriate simplifications, the method gives the same results as the elementary theory. As the author points out, similar problems involving concentrated loads have been solved by Barten, Bisshopp, and Drucker. Method may be useful when shallow members or materials of low modulus of elasticity are involved. L. Schenker, USA

738. Gray, C. A. M., An iterative solution to the effects of concentrated loads applied to long rectangular beams, *Quart. appl. Math.* **11,** 3, 263–271, Oct. 1953.

An infinite strip resting on two point supports and placed in a state of generalized plane stress by a concentrated load midway between them is analyzed by the method due to Mushkelishvili. The loaded strip is conformally transformed to a unit circle, the boundary conditions are also transformed, and the problem is solved in the plane of the circle. Compared with previous treatments of the same problem, this one has the advantage of yielding a direct solution in the form of a power series. The coefficients in the power series are determined by an infinite set of simultaneous linear algebraic equations and the set is solved by iteration (following truncation), which gives rise to the use of this term in the title.

The author obtains explicit corrections to the usual engineering formulas for curvature and deflection. These corrections are useful and instructive. L. E. Goodman, USA

739. King, W. B., and Garrison, W. R., Differential shear-flow analysis for nonprismatic semimonocoque beams, *J. aero. Sci.* **20,** 2, 127–135, Feb. 1953.

A method is devised for the determination of shear stresses in nonprismatic beams, based on actual rates of change of axial load at stations along the span rather than average rates in the bays between stations. Author claims method is more accurate than "Unit method of beam analysis" of Shanley and Cozzone [title source, **8,** 6, p. 246, Apr. 1941].

The method is subject to all of the limitations of the assumptions of classical beam theory. Thus it is of little use for the accurate calculation of stresses in complex wing structures for which the concept of a shear center and the resulting differentiation between bending and torsion are inapplicable.

P. Seide, USA

740. Sattler, K., Yield design of compound steel-concrete beams (in German), *Bautechnik* **30,** 6, 153–160, June 1953.

Paper contains discussion of methods for computing yield load or proving required safety against yielding of compound beams consisting of steel girder and normal or prestressed-concrete wide flange. It is argued that stresses caused by creep, shrinkage, or temperature differentials may be neglected in computing yield or ultimate loads and that yield design is to be preferred over ultimate load design. Yield requirements are proposed; failing load is assumed to be about 10% in excess of yield load. Both statically determinate and statically indeterminate (continuous) beams are considered and the proposed methods are illustrated by a number of examples. F. J. Plantema, Holland

741. Borusiewicz, W., Calculation of prestressed beams by means of core points (in Polish), *Inżyn. Budown.* **8,** 10, 387–391, Oct. 1951.

Author presents a method of static analysis for calculation of prestressed beams having sections most used in practice (rectangular, T-, and I-form), treating his contribution in connection with paper of B. S. Kartseff [*Ann. Trav. publics. Belg.* **97,** 3, 265–286, 1944]. In his analysis author uses the core moments. Four simple formulas define the limit conditions of elastic state of beam. W. Olszak, Poland

742. Shapiro, G. S., Certain problems for deformations of rods of variable cross sections (in Russian), *Prikl. Mat. Mekh.* **17,** 2, 249–252, Mar.-Apr. 1953.

State of stress of a bar of variable cross section and of the form of revolution, loaded in simple tension, can be solved by a stress function in polar coordinates, using the condition of equilibrium of external and internal forces and boundary conditions. The result is a series giving approximate solutions by using a limited number of members. Another case considered by the author is a

bar of rectangular cross section with constant width and variable height, solved also by a series. In both cases, one finds that, by neglecting certain functions, the elementary solution of the strength of materials is obtained. Z. Bažant, Czechoslovakia

743. Onat, E. T., and Shield, R. T., Combined bending and twisting of thin tubes in the plastic range, *J. appl. Mech.* **20,** 3, 345–348, Sept. 1953.

See AMR **6,** Rev. 3359.

744. Okubo, H., Torsion of a circular shaft with diameter varying periodically along its length, *ZAMP* **4,** 3, 197–207, 1953.

Expressions are developed for the stresses and stiffness of a circular shaft in torsion and having moderately deep circumferential grooves periodically spaced. The stress function for the shaft of variable cross section is taken as a series of combinations of Bessel and trigonometric functions in which the coefficients are chosen to satisfy approximately the boundary conditions.

Numerical evaluation is made for a shaft with grooves which have the same pitch and depth as a Whitworth screw. The distribution of shearing stress as a function of radial position is indicated for cross sections corresponding to the minimum and maximum diameter. The error introduced by incomplete satisfaction of the boundary condition is estimated by showing that the boundary stress is negligibly small on the free boundary. The stiffness of the threaded shaft is shown to be slightly larger than the unthreaded shaft having the minimum diameter of the threaded shaft. M. V. Barton, USA

745. Griffith, G. E., Stresses in a two-bay noncircular cylinder under transverse loads, *NACA Rep.* 1097, 12 pp., 1952.

Supersedes article reviewed in AMR **5,** Rev. 650.

746. Rossetti, U., Fatigue strength of wire ropes. Endurance test under combined bending and tension (in Italian), *Ingegnere* **27,** 7, 769–771, July 1953.

Emphasis is placed on correct and exact determination of cable strength under dynamic test. A new fatigue-testing machine is described and the advantages and adaptability of the equipment used are discussed briefly. Experiments were conducted on several types of wire ropes. Comparative results of the behavior of every type under fatigue test are also presented.
C. A. Sciammarella, Argentina

747. Robertson, S. C., and Dunstant, R. A., Bending of wire ropes in flying foxes, *J. Instn. Engrs., Austral.* **25,** 3, 45–51, Mar. 1953.

In this study the cable is analyzed as a beam loaded with an axial tension force and concentrated lateral loads from the carrier wheel or wheels. This assumption leads to the usual hyperbolic solution.

The principal assumptions are that the sag of the cable is fairly small, generally not exceeding $^1/_{10}$ of the span, although the results are roughly true for a sag of $^1/_5$ of the span, and that the elastic limit is not exceeded.

Expressions for the bending moment and the equivalent tension due to bending moment are given for the case of a single wheel carrier on a flying fox, and also for the cases of double- and multiple-wheel carriers.

These expressions define in normal conditions upper limits to the bending moment and the equivalent tension. Values determined from them will not generally be exceeded in practice, nor will the actual moments and equivalent tensions be less, except possibly in the case of very flexible ropes passing over exceptionally large sheaves in single- or perhaps double-wheel carriers in a flying fox with a relatively large sag ratio.

The results may be extended to ropes passing over sheaves generally, provided that the angle turned through by the rope does not exceed 45° as an absolute maximum.

Some practical results are given, including rough figures to indicate the conditions when the elastic limit of the wires is exceeded. From authors' summary by W. J. Carter, USA

748. Niemann, G., and Heyer, E., Investigations on worm gears (in German), *ZVDI* **95,** 6, 147–157, Feb. 1953.

Worm gears with ground cylindrical teeth, made of tempered steel, and worm wheels made of bronze were the objects of the test. Author shows how the hydrodynamic load-bearing capacity, friction, and the roller pressure at every point of the wheel flank (wheel plate) can be evaluated from the direction and the axial distance. In this instance, worm wheels with concave flanks are more suitable than the usual worm wheels with convex flanks—e.g., involute gears.

In preliminary tests, the cooling capacity of the casing (box) during varied operating conditions was measured; the dissipated heat was in equilibrium. Likewise, the idling capacity (no-load capacity) and the supplementary power loss (= dissipation) in consequence of the axial bearing load of the worm drive shaft were measured. In this manner, the dissipation of the gearing could be separated from the total power loss of the gears, and from this it was possible to determine the efficiency of the gearing and its coefficient of friction. In a gear box with cooling fins, five worm gears with an axial distance of 100 mm and a speed reduction of 20:1, with and without blast deflector on the worm shaft (i.e., worm drive shaft), were tested in a continuous operation.

Variations were introduced in the tooth form of the worm gear (convex, concave), the size of the tooth (module 2.5–6.5 mm), the medium worm-gear diameter (42–63 mm), the brand or type of lubricating oil (2 gear oils and 1 hypoid oil), the viscosity and the temperature of the oil, respectively, the depth of immersion of the helix (worm), the revolutions per minute of the worm gear (380–1470 rpm), and the rotation moment of the wheel (0–55 mkg). Measurements were made of the rotation moment at the drive start and at the output drive, the temperature of the oil sump, and on the external wall of the gear box level with the center of the helix, the temperature of the air in the testing laboratory, and of the electrical-current transfer from the helix (worm) to the wheel. The individual component parts are given. They depend chiefly on the cooling capacity of the gear box, the idling capacity (no-load capacity), the bearing or carrying load, the helical (worm) diameter, the size of the teeth, and the proper selection of a lubricating oil. L. Föppl, Germany

749. Vidéky, E., Analysis of gear friction, *Acta Techn. Hung., Budapest* **6,** 3–4, 239–259, 1953.

Author has summarized the various factors which enter into the design of gears. He gives formulas for stresses in gears, based on the work of Hertz. A good summary of the problem of friction is given. Finally, the problem of lubrication and its breakdown is treated. The article closes with suggestions for gear design, for manufacture and assembly, and for operation. The reviewer believes the paper to be a good, concise summary of the factors that enter into gear design. V. P. Zimnoch, USA

750. Russell, J. E., and Chesters, W. T., The significance of the Izod test with regard to gear design and performance, *Engineering* **176,** 4567, 166–169, Aug. 1953.

Paper describes the results of an investigation sponsored by the Admiralty-Vickers Gearing Research Association to deter-

mine the significance of Izod values with regard to gear performance. Special specimens were constructed in which conditions of stress, when subjected to impacts in the Izod machine, were similar to those occurring in a gear tooth. Curves were obtained of the amount of energy required to fracture these specimens vs. the amount of energy required to fracture standard Izod specimens for each of a variety of materials. Tests were performed at different temperatures (down to −196 C) in order to obtain a wide range of fracture energies. The results indicate relatively small changes of energy to fracture for the special specimen as compared to the standard. It is concluded that there is little value in requiring gear material to have an Izod value in excess of 5 ft-lb, as far as shock loading is concerned, although for special cases a 10 ft-lb value might be justified. I. Vigness, USA

Plates, Disks, Shells, Membranes

(See also Revs. 717, 732, 761, 767)

751. **Mansfield, E. H., The diffusion of load into a semi-infinite sheet. Parts I and II,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2670, 61 pp., June 1948, published 1953.

Study is made of the transfer of load from a stringer to sheet with particular emphasis on the stresses in the sheet along the line of attachment of the stringer.

Expressions are developed for the stresses in a semi-infinite sheet caused by a concentrated load in the plane of the sheet and perpendicular to the free edge. These solutions are obtained by superimposing the stress functions for a force in an infinite sheet with the stress function required to produce zero resultant stress along a line in the sheet perpendicular to the load. The solution of this basic problem is used to obtain the shear stresses adjacent to a stiffener by matching strains along a line of attachment between stringer and sheet. These shear stresses are expressed in terms of integral equations which are not easily solvable. It is shown, however, that very high shear stresses are present adjacent to the stringer and near the free edge of the sheet.

Investigation is made of the use of stiffeners perpendicular to the stringers and placed along the free edge of the sheet to relieve the high stresses near the edge and adjacent to the stringer.

M. V. Barton, USA

752. **Grinberg, G. A., Method, proposed by P. F. Papkovich, for the solution of plane problems in the theory of elasticity for a rectangular region, and of the problem of bending of a rectangular thin plate with two clamped edges, and on some of its generalizations** (in Russian), *Prikl. Mat. Mekh.* **17**, 2, 211–228, Mar.-Apr. 1953.

P. F. Papkovich ["Ship structural mechanics," Leningrad, 1941] reduced the bending problem of a rectangular plate, with opposite edges clamped, and the plane problem of the theory of elasticity, to finding the expansions of two real functions $f_1(y)$, $f_2(y)$, in a given interval, in series of the type $f_s(y) = \Sigma a_k L_i[F_k(y)]$, a_k being undetermined complex constant coefficients, equal in both series, L_i being two different linear operators with constant coefficients, which depend on the particular problem, and F_k being a function determined from a given fourth-order differential equation and boundary conditions. F_k are called Papkovich functions.

Author investigates the mathematical foundations of the method, such as the convergence of the series, and extends its applicability to domains bounded by coordinate lines in polar coordinates. Good approximation to the solution should be obtainable, for example, in the case of uniform loading on a semicircular plate, free along the diameter and clamped along the circular edge. G. Herrmann, USA

753. **Hognestad, E., Yield-line theory for the ultimate flexural strength of reinforced concrete slabs,** *J. Amer. Concr. Inst.* **24**, 7, 637–656, Mar. 1953.

Paper presents the outline of the theory developed primarily by Prof. K. W. Johansen of the Danish Institute of Technology in Copenhagen. The theory consists in the application of principles of limit design to concrete slabs of arbitrary shape, edge conditions, and loading, reinforced in one or two directions. The limit moment in the slab is assumed to correspond to simultaneous action of the yield stress in steel and ultimate compression stress in concrete, under which conditions a plastic line hinge forms. When the load reaches the limit value, both positive and negative plastic line hinges develop, breaking the slab into sections, rotating in relation to each other about the hinge lines and the lines of free supports. The limit load is then determined either by statics alone or together with the principle of maximum energy, whose legitimacy, by the way, is taken for granted.

Some of the assumptions involved in the theory are as follows: (1) The slab failure is not due to either shear or load stresses or to compression in concrete developed prior to yielding of steel. For this condition the percentage of reinforcement in each direction must be small—less than 0.5–1%. The author, however, does not show how this percentage is affected by values of the ultimate stress in concrete and the yield stress in steel. (2) The plastic hinge lines are assumed straight, looking in plan. (3) No shear forces are transmitted across plastic hinges except for concentrated point shears assumed present at intersections of hinge lines with free and simply supported edges. To the reviewer, the nature of these shears is not fully clear and the derivation of their value appears unconvincing.

A number of examples, illustrating the application of the theory, are given.

In spite of some objections, reviewer considers this paper very interesting and valuable from the viewpoint of practical design.

A. Hrennikoff, Canada

754. **Márkus, G., Analysis of circular plates by the method of moment distribution** (in Hungarian, with English and German summaries), *Vízügyi Közlemények* no. 1, 44–80, (15)–(29), 36 pp. of diagrams, 1952.

The method of moment distribution is applied to circular and annular plates exactly in the same way as to continuous girders. Signs of the initial fixed-edge moments are determined for the part of the plate to the left of its center. Distribution of moments is made only for radial moments. Tangential moments are determined from radial moments on supports, already computed. The determination of moments M_r and M_t is made in each case in three steps: First, the moments are determined for the freely supported plate in case of loading acting within the span; secondly, for the same plate span moments due to continuity of the plate or to fixed-edge moments are determined; finally, these two are summarized. The same method is followed in determining reactions. It is commendable to do the calculation in a tabular form.

From author's summary by D. Vasarhelyi, USA

755. **Klöppel, K., and Jungbluth, O., Contribution to the problem of buckling in thin-walled spherical shells (Experiments and design specifications)** (in German), *Stahlbau* **22**, 6, 121–130, June 1953.

In tests under uniform external pressure, spherical shells buckle at as low as 1/4 of the load predicted by the theoretical formula obtained by Zoelly ["Uber ein Knickproblem an der Kugelschale," Diss. Zurich, 1915] using classical methods; and at less than the theoretical value for other loading conditions. Edge conditions and plastic phenomena are not sufficient to explain this. Von Kármán and Tsien [*J. aero. Sci.* **7**, pp. 43, 276, 1939–

1940] used an arbitrary numerical value for an initial imperfection and obtained a value about 30% as large as Zoelly's.

This paper presents, together with a discussion of these and other theories, the results of experiments on thin spherical steel domes capping a cylinder and loaded by air pressure. The buckling process was filmed at 1000 frames per sec as the domes underwent a complete reversal of curvature. Resulting pictures show that buckling is not rotationally symmetrical, as most theoretical studies have assumed. Empirical formulas and curves obtained show even von Kármán and Tsien to be unconservative. Stiffened shells having angle stiffeners welded to the skin at the toe, heel outward, in a variety of stiffener patterns were also tested and filmed. Meridional stiffeners were found more effective than ring stiffeners.

Experiments and resulting empirical formulas for both stiffened and unstiffened shells apply to domes having edge slopes of 20° to 60° and $400 < R/t < 2000$.

Experiments now under way with shells loaded over half their surfaces will be reported on later. A. D. Topping, USA

756. Vodička, V., The deflection of sandwich plates with light filling (in German), *ZAMM* **33,** 5/6, 188–199, May/June 1953.

Author gives a general solution for the statical bending problem of sandwich plates with $2n + 1$ parallel and symmetrically orientated plate parts. The middle region is supposed to consist of a light material with negligible elastic resistance. Using some further simplifying assumptions but attending the complete set of boundary conditions, all components of stresses and displacements are reduced to six stress functions, which follow a linear differential equation of high order. The paper gives a more general theory than a similar paper of Prusakow [*Prikl. Mat. Mekh.* **15,** 26–35, 1951] concerning the three-plate system.

H. Neuber, Germany

Buckling Problems

(See Rev. 755)

757. Habel, A., Bearing capacity of centrally loaded reinforced-concrete columns (in German), *Beton u. Stahlbeton.* **48,** 7, 153–160, July 1953.

Author presents results of comprehensive analytical investigations of the buckling load of centrally loaded reinforced-concrete columns using the Engesser-von Kármán (double modulus) theory. The moment of inertia of the cross section is taken as that of full concrete section without steel about the appropriate axis, the influence of steel ratio and of shape of stress-strain diagrams for concrete and steel being allowed for by appropriate definition of the "buckling modulus."

Separate studies are made of the effect of ultimate strain in the concrete, form of stress-strain curve, ultimate strength of the concrete, grade of steel, steel ratio, and shape of the cross section. The influence of pretensioned steel and of creep and shrinkage in concrete is also examined. Studies are then extended to include influence of transverse loading, influence of initial curvature of column axis and of elastically restrained ends.

For transversely loaded columns, the procedure is to assume end load and central deflection. Form of deflection curve and the transverse load are then deduced by finite difference methods, using previously plotted bending-moment-curvature relation for the given end load. A plot of transverse load against central deflection then shows limit of stability. With relatively high end load, column may fail by crushing of concrete before stability limit is reached.

Brief comments are added on columns with steel ratio varying along length and on influence of weight of column itself. Author concludes that the former is not worth while and that the latter may be neglected except perhaps in columns of very large bridges. A. Burn, Australia

758. Habel, A., Bearing capacity of eccentrically loaded reinforced-concrete columns (in German), *Beton u. Stahlbeton.* **48,** 8, 182–190, Aug. 1953.

Author extends his methods (see preceding review) to cover the case of eccentric loading. Methods of analysis are more fully described and both papers should be read together.

In determining moment-curvature relation for given end load, author remarks that, since as a rule both thrust and moment increase together to their final values, it is advisable to use normal stress-strain diagrams for concrete and steel over whole cross section, and not to use unloading (initial modulus) diagram on the bending-tension side, as was done in applying the Engesser-von Kármán theory to the centrally loaded column.

Areas where bending tension exceeds direct stress are excluded, crack formation being assumed.

Author also notes that ultimate strain in concrete is greater in bending than in direct compression. For example, in one case he takes ultimate strain 1.2% when direct stress is 200 kg/cm² (2840 psi) without bending, and 3% for bending only, interpolating for intermediate values of direct stress.

Comparison is made of results using true form of deflection curve based on bending-moment curvature relation with approximation using sine curve. Latter is shown to be conservative.

Studies include influence of shape of stress-strain diagram, shape of cross section, elastically restrained ends, buckling at right angles to the plane of loading, brief comments on shrinkage and creep, and comparison of results with latest German regulations (DIN 1045). Author concludes that in many cases factor of safety of eccentrically loaded columns designed by these rules is far too small.

Both papers are well worth serious study, but a little care is needed in reading them. For instance, the symbol k is used both for curvature and for core radius. Use of p for eccentricity of load is at first confusing. Slenderness ratio is arbitrarily defined as l/i, where i is the radius of gyration of the gross concrete section omitting the steel, and critical compressive stress is defined as critical-load/gross-concrete-area. A. Burn, Australia

759. Libove, C., Creep-buckling analysis of rectangular-section columns, *NACA TN* 2956, 24 pp., June 1953.

A pin-ended column of rectangular section with slight initial curvature is analyzed. The stress-strain-time relationship is assumed to be of the form $\epsilon = (\sigma/E) + Ae^{B\sigma}t^K$ where ϵ is the total compressive strain, σ is the constant compressive stress, and E, A, B, and K are material constants. The deformed column is assumed to remain sinusoidal at all times. The equilibrium condition is satisfied only at the midheight section of the column. Graphs of column lifetime vs. an initial straightness parameter and the ratio of the average applied stress to the Euler stress are shown. T. H. Lin, USA

760. Yamaki, N., Buckling of a rectangular plate under locally distributed forces applied on the two opposite edges (1st and 2nd Reports), *Rep. Inst. high Speed Mech., Tōhoku Univ.* **3,** 71–98, Mar. 1953.

Both reports treat plate buckling under loads uniformly applied over the central portion of two opposite edges. In the first report, four cases are treated which include all combinations of simple support and clamped edges with opposite edges supported alike. The energy method is used and a simplified stress distribution is

implied in the method of solution. Numerical results are given for a variety of aspect ratios and ratios of length of loaded segment to total length of edge.

In the second report, loaded edges are always simply supported and other two edges are simply supported, clamped, or free. Plate partial-differential equation is converted to ordinary differential equation by assuming a sinusoidal deflection in direction of loading. Solution of resulting equations leads to a sixth-order determinantal equation. Numerical results are given in tables. In those cases where the same problem is treated both ways, results are very close. S. B. Batdorf, USA

761. Hopkins, H. G., The plastic instability of plates, *Quart. appl. Math.* **11,** 2, 185–200, July 1953.

Author derives relations between excess stresses and excess strains for incipient buckling of plates, using flow theory. Reviewer remarks that, except for use of other parameters, these are identical to those found by himself as a special case of deformation theory [*Proc. k. Ned. Akad. Wet.* **41,** p. 468, 731, 1938].

Besides considering the Shanley problem, author assumes that at incipient buckling, loads do not increase (von Kármán problem), and he derives differential equations for this case, which, however, appear too difficult to solve. He finds that boundary surface between elastic and plastic region is not flat, as was found in some previous papers.

Reviewer pointed out incorrectness of flat boundary surface in his review [AMR **1,** Rev. 804] of Ilyushin's paper. Results from this flow theory will disagree with test results.

P. P. Bijlaard, USA

Joints and Joining Methods

(See Rev. 818)

Structures

(See also Revs. 736, 741, 753, 756, 757, 758, 789, 790, 800, 801)

762. Wang, C.-K., Statically indeterminate structures, New York, McGraw-Hill Book Co., Inc., 1953, x + 424 pp. $7.50.

The text treats the analysis of indeterminate structures consisting of linear elements (beams, frames, and trusses). Problems treated provide an excellent choice of material for senior course in civil engineering. Author emphasizes use of method of consistent deformations in solving specific problems and in deriving formulas or equations to be solved.

After a general introduction, two chapters are devoted to the calculation of deflections of statically determinate structures. The unit-load method and moment-area principles are used extensively for computing deflections. Castigliano's theorem is introduced and used briefly. Lack of mention of virtual work meets with reviewer's approval for this field of structural analysis.

After a thorough study of deflections, author proceeds logically to present method of consistent deformations for analyzing beams, frames, and trusses. Theorem of least work is introduced and illustrated briefly.

A short chapter is devoted to the equation of three moments for uniform continuous beams. This is followed by three rather long chapters treating, successively, the method of slope deflections, moment distribution, and the column analogy.

Author feels that moment distribution should not be taught alone but should be accompanied by, or preceded by, method of slope deflection. Reviewer agrees, but would prefer to see less emphasis upon the method of slope deflection with more space devoted to moment distribution, due to its more frequent usage in practice.

Chapter on column analogy is well organized to carry the reader through a rather long series of problems of gradually increasing complexity. A short chapter is devoted to the calculation of secondary stresses in trusses by moment distribution. The last chapter treats the analysis of "composite" structures such as king post and queen post trusses.

A few minor criticisms seem desirable. In the derivation of the unit-load method and Castigliano's theorems it should be emphasized that superposition is permissible because of assumed linearity between loads and displacements. While the solutions given in the last chapter for composite structures are in agreement with other textbooks, reviewer feels that readers should be warned that the method of solution is only approximate, since these structures have nonlinear force-displacement relations. For rigorous solutions, complementary energy should be used in Castigliano's theorems rather than strain energy. Reviewer prefers the simple algebraic derivation of the column analogy as originally given by Hardy Cross. Limitation of nonuniform beams to stepped variation of stiffness seems narrow. Haunched beams should be mentioned, at least by reference.

This introduction to indeterminate structures is written in a style that is clear and easily understood with a minimum usage of advanced mathematics. Author presents, in considerable detail, a small but well-chosen category of problems. Text should not only serve well for teaching purposes but will be useful as a reference because of the large number of examples worked out in complete detail. S. U. Benscoter, USA

763. Michalos, J., Numerical analysis of frames with curved girders, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 250, 21 pp., Aug. 1953.

Author applies Hardy Cross method of moment distribution to analysis of frames consisting (partly) of members of uniform section and circular arcs. Loading is such that the curve members experience torsion and bending out of the plane of curvature, but no bending in the plane of curvature (i.e., the vectors representing the torques and moments lie *in* the plane of curvature). Table of stiffnesses and carry-over factors are given for various situations.

M. P. White, USA

764. Olander, H. C., A method for calculating stresses in rigid frame corners, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 249, 21 pp., Aug. 1953.

765. Filin, A. P., Determination of redundands in physically nonlinear, statically indeterminate structures (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **89,** 4, 639–642, Apr. 1953.

Author investigates the influence of the plastic flow of concrete to the magnitude of redundands in statically indeterminate beam and arch systems. By using the method of virtual work, author derives the nonlinear equations for the additional work, done by plastic flow in such systems, and proves that the plastic flow causes a significant increase in bending moments and advocates taking into account the influence of creep of concrete in arch systems. J. B. Gabrys, USA

766. Hosek, J., Solution of the effect of an opening in a thin shear wall by the method of increments of shear flows from the opening, *Engng. Rev., Prague* no. 7, 1–14, Feb. 1951.

A method whereby the effect of an opening in a statically indeterminate shear wall, such as thin-walled web girders, can be solved by means of solutions of statically indeterminate systems where the shear wall is replaced by a system of bars or by a

method of increments of the shear flows from the opening. The solution assumes that (a) the walls resist shear stresses, (b) the shear walls do not transmit in-plane bending stresses, and (c) the effect of distortion of struts is neglected.

Only the case of a wall of uniform thicknesses of the same material is solved; however, the calculations may be extended to cases of arbitrary wall thicknesses. C. B. Matthews, USA

767. Lévi, F., Theoretical and experimental analysis of a prestressed plate on elastic supports, loaded beyond the elastic limit (in French), *Ann. Inst. tech. Bât. Trav. publics* **6,** 66, 535–556, June 1953.

Report deals with results of test performed on prestressed slabs at Casselle airport at Turin. Interpretation of results is made by means of theory of coactive slabs. Experimental setup and apparatus are described in detail. Results of theoretical study of slab on elastic foundation are given and used to interpret test information. Author considers elastic (stress) phase and inelastic (deformation) phase. Under elastic phase, test results are plotted and sample computations are given. Comparative tests performed on an ordinary concrete slab are described. Procedure outlined in paper seems to offer a satisfactory basis for analyzing slabs on elastic foundation. R. B. B. Moorman, USA

768. Heyman, J., Plastic design of plane frames for minimum weight, *Struct. Engr.* **31,** 5, 125–129, May 1953.

Limit design by means of minimum weight of plane frames as a whole, or by minimum weight of separate parts, is proposed. Design is based on linear ratio between weight and plastic moment. Upper and lower bounds for collapse loads are determined; actual minimum weight lies between these bounds. Lower bounds are determined by assuming location of plastic hinges in each part separately and then determining value of plastic moment. Minimum weight equals summation of product of plastic moment and length for each part. Upper bound is determined similarly, but by combining parts. The method uses a kinematic solution to obtain an equilibrium solution; work of loads equals work at plastic hinges. Several examples are given; terms and propositions are defined. Limits of material consumption are sufficient for practical purposes. C. M. Smith, USA

769. Levy, S., Structural analysis and influence coefficients for delta wings, *J. aero. Sci.* **20,** 7, 449–454, July 1953.

Paper obtains influence coefficients for delta wings in matrix form suitable for use in high-speed computing machines. Procedure is sufficiently general to allow for nonparallel spars and ribs and for large cutouts in skins. Skins are assumed thin relative to spar webs, and their effectiveness in direct stress is taken into bending stiffness of ribs as well as spars.

Final stiffness matrix is obtained by adding stiffness influence coefficients due to spars, ribs, and "torsion boxes" between adjacent pairs of spars and ribs. K. H. Griffin, England

770. Janik, F., The development of aircraft structural airworthiness requirements (in Polish), *Tech. Lotnicza* **7,** 5, 126–135, Sept.-Oct. 1952.

Author reviews the principal items contained in the structural airworthiness requirements and gives a brief historical survey of the load requirements.

Discussing the flight envelope, introduced originally as far back as 1937 in the Polish requirements, author compares the different known national and international structural airworthiness requirements. In his conclusion he underlines the necessity of (1) the introduction of influence lines to the strength analysis of different aircraft parts; (2) the revision of the coefficient, taking into account the finite gust gradient for the determination of gust loads; (3) the reduction of the number of combined load cases.

Z. Brzoska, Poland

771. Franciosi, V., Flexo-torsional instability in high prestressed concrete beams (in Italian), *G. Gen. civ.* **91,** 4, 172–180, Apr. 1953.

The objective of this paper is to study the lateral instability of high precompressed beams of rectangular cross section. The author used the variational method of Ritz, and claims that the approach can be used as well for beams of any cross section. The results obtained show that there is no danger of flexo-torsional instability because of the precompression, and that this load has some helpful effect in stabilizing the applied loads.

From author's summary by A. J. Durelli, USA

772. Libby, J. R., The elastic design of simple prestressed concrete beams, Proc. Western Conf. Prestressed Concrete, Univ. of Calif., Los Angeles, Nov. 1952, 71–101, Jan. 1953.

773. Guyon, Y., Prestressed concrete, New York, John Wiley & Sons, Inc., 1953, 543 pp. $12.

See AMR **5,** Rev. 1701.

774. Pietkowski, R., Earth pressure on the tunnel lining (in Polish), *Inżyn. Budown.* **9,** 11, 359–363, Nov. 1952.

Author examines the problem of determining the values of earth pressure on a tunnel lining in connection with the intended construction of a subway in Warsaw. Taken into consideration are the vertical and lateral pressures and also their mutual relation. The paper contains a comparative analysis of most frequently used methods and formulas. Among them are the methods based on theoretical examinations, and also explained are the methods resulting from actual measurements of pressures in constructed tunnels. Here the studies of Terzaghi, Housel and Krynine, among others, are helpful. In conclusion, author emphasizes the impossibility of computing the pressures on the tunnel lining with such exactitude as can be done in overground structures, and advises determining in every case the expected limiting values of pressure conforming to the soils actually found in place. H. Stamatello, Poland

775. Anonymous, Spillway for Folsom Dam, American River, California, *Wwys. Exp. Sta. tech. Mem.* 2-369, 141 pp., Aug. 1953.

The spillway for Folsom Dam, Calif., the flow over which will be controlled by eight gates, was studied concurrently on two almost identical 1:80-scale models in the laboratory of the Waterways Experiment Station, Vicksburg, Miss. Two models were necessary because of the urgent need for a decision as to the type of energy dissipator to use at the toe of the spillway. A flip-bucket-type energy dissipator was investigated on one model, and a conventional type stilling basin was tested on the other.

Although tests revealed that the flip-bucket-type energy dissipator was adequate as far as the safety of the dam was concerned, the stilling-basin type was adopted for construction downstream from the five gate bays adjacent to the right abutment because it will afford greater safety to the powerhouse and reduce possible maintenance costs after completion of the dam. The extra cost of the stilling basin was considered warranted in view of the increased energy dissipation secured. The flip-bucket-type energy dissipator also will be constructed downstream from the three gates adjacent to the left abutment. However, flow will be confined to the five spillway bays discharging into the stilling basin, except for extreme emergencies.

From summary by A. L. Jorissen, USA

776. Biggs, J. M., Wind loads on truss bridges, *Proc. Amer. Soc. civ. Engrs.*, **79,** Separ. no. 201, 19 pp., July 1953.

Author presents results of wind-tunnel tests on two scale models of typical truss bridges. Both railroad and highway bridges are represented. Variables include single vs. double trusses, types of floor, location of floor, spacing of trusses, three different wind velocities, and angle of yaw. Comparisons are made with existing specification requirements. The spacing of trusses was found to be one of the most important variables, a conclusion which is interesting because this factor is ignored in existing specifications. For a relatively narrow two-lane highway bridge the overturning moment was found to be 50% greater than that normally used in design. The investigation was a by-product of research for the U. S. Army Corps of Engineers and, in reviewer's opinion, marks an important forward step in a portion of the structural field which has been largely neglected for many years. E. C. Hartmann, USA

777. Vincent, G. S., Investigation of wind forces on highway bridges, *Nat. Res. Counc. Highway Res. Bd., spec. Rep.* 10, 30 pp., 1953.

Report describes wind-tunnel tests on models of girder, pony, and through-truss bridges. Wind velocities in the range from 25 to 100 mph indicated the absence of scale effects.

A specified wind load of 50 psf on 1.5 times the area in elevation appears adequate for trusses without live load when subjected to 100-mph winds. The loads for pony trusses and deck girders might be somewhat less. Longitudinal forces of 50% for trusses and 25% for girders seem reasonable.

The tests at 100 mph and an upward angle of 10° do not account for the very high overturning forces that must have occurred to cause certain failures. Marshall Holt, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 727, 743, 768, 814, 958)

778. Odqvist, F. K. G., Influence of primary creep on stresses in structural parts, *Trans. roy. Inst. Technol., Stockholm* no. 66, 17 pp., 1953.

The paper shows how primary creep (to make creep stress dependent on total stress as well as, independently, on strain rate) may be taken into account within a purely phenomenological theory. This theory has possibilities of extension to general three-dimensional stress systems. Author presents an application of the creep-stress distribution of a rotating disk with uniform thickness. He concludes that a redistribution of the stress takes place as a consequence of primary creep and that generalization to real gas-turbine disks with nonuniform thickness and temperature should meet with no essential difficulty.

C. O. Dohrenwend, USA

779. Koiter, W. T., Stress-strain relations, uniqueness and variational theorems for elastic-plastic materials with a singular yield surface, *Quart. appl. Math.* **11,** 3, 350–354, Oct. 1953.

Paper is concerned with a plastic-elastic material for which the yield function and potential are identical but not everywhere regular; i.e., the surface representing them in stress space does not possess a unique normal at certain points. Existing proofs of extremum and uniqueness theorems for a completely regular potential are extended by author to cover singular potentials. In proving that the basic inequalities are still true, it is assumed only that at a singular point the direction of the associated plastic strain-rate vector does not lie outside the range bounded by the outward normals at neighboring regular points.

Reviewer notes that this restriction, and hence the basic inequalities, follow if a singular potential is regarded as the limit approached by a regular potential when one or both of the principal radii of curvature tend to zero at certain points. From this standpoint, therefore, author's proofs appear to be superfluous. R. Hill, England

780. Thomas, T. Y., Singular surfaces and flow lines in the theory of plasticity, *J. rational Mech. Anal.* **2,** 2, 339–381, 1953.

Author gives a mathematical discussion of certain properties of so-called singular surfaces in a spatial region, dealing in particular with types of discontinuity of functions across such surfaces. He applies theory to the problem of flow lines on the surface of plastically strained body, treating these as intersections of the surface of specimen with singular surfaces in specimen. With special consideration of simple tensile or compressive stress states, author investigates two significant types of singular surface, one of which corresponds to the usual slip lines on specimen.

D. N. de G. Allen, England

781. Osipov, K. A., Fedotov, S. G., and Lozinskiĭ, M. G., "New" mechanism of the plasticity of solid solutions of metals (in Russian), *Doklady Akad. Nauk. SSSR (N.S.)* **89,** 1, 57–60, 1 plate, 1953.

Wood and others [AMR **3,** Rev. 477; **4,** Revs. 206, 674, 1154, 2059, 2918; **5,** Rev. 2028] have observed that at high temperatures and low strain rates, aluminum and zinc deform not by formation of slip bands but by breaking up of large grains into fine ones, which undergo relative movement. Authors report similar observations on copper-tin alloys (2, 5, 8, and 12% tin) above 425 to 525 C. They incline to the view that the fine-grain structure is already present before deformation but becomes clearly observable upon relative movement of the grains, and that the basic mechanism is viscous flow at the grain boundaries. Several experimental facts are cited as supporting this interpretation.

Wm. Fuller Brown, Jr., USA

782. Mewes, E., Structure model and mechanism of the flow process (in German), *Ing.-Arch.* **21,** 2, 104–111, 1953.

Author discusses in detail some conventional linear models and then considers qualitatively some nonlinear models, as representations for Bingham and Saint Venant bodies. B. Gross, Brazil

783. Vitovec, F., The existence of a yield point as a stability problem (in German), *Öst. Ing.-Arch.* **7,** 1, 4–11, 1953.

Tension measurements by means of x rays have yielded the result that even with mild steel the plastic deformation starts in portions of the surface already with stresses having the same order of magnitude as the yield point of single crystals. Assuming a specified distribution of the local yield points, the pronounced yield point is treated as a stability problem in which the influence of a stress gradient is investigated in detail.

From author's summary by M. A. Meyer, South Africa

784. Prager, W., On the use of singular yield conditions and associated flow rules, *J. appl. Mech.*, **20,** 3, 317–320, Sept. 1953.

Following Koiter [AMR **6,** Rev. 2778], author shows that a considerable simplification of the mathematical work in problems of plane plastic stress is possible by the joint use of Tresca's yield conditions and the associated flow rule. Method is discussed in connection with two examples concerning the finite enlargement of a circular hole in an infinite sheet of perfectly plastic or work-hardening material.

From author's summary by S. C. Das, India

785. **Folberth, O. G., and Kochendorfer, A., Theory of creep in single crystals** (in German), *J. Mech. Phys. Solids* **1**, 4, 244–257, July 1953.

Utilizing the Boltzmann principle, authors derive expressions for creep involving primary (transient initial decelerating creep) and secondary (steady-state linear creep), but not the tertiary accelerating creep which leads to failure. Expressions are derived for creep velocity at different temperatures and from these are developed predicted creep curves which check well with experimental results. Shear creep, creep velocity, shear stress intensity, strain hardening, and activation energy are all taken into account. A simplified mathematical approach is presented at the end. As a semiempirical, fairly simple approach, the treatment is interesting. A. G. H. Dietz, USA

786. **Pugh, H. L. D., A note on a test of the plastic isotropy of metals,** *J. Mech. Phys. Solids* **1**, 4, 284–286, July 1953.

Taylor and Quinney [*Phil. Trans. roy. Soc.* (*A*) **230**, 323, 1931] assumed that thin-walled tubes of metal were isotropic if the internal volume of the tube did not change when it was plastically deformed by axial tension and if the directions of the principal axes of stress and strain increment coincided during the course of the deformation experiments. The present author shows that if a tube has a certain type of anisotropy which is rotationally symmetrical about the axis of the tube, then this tube will pass the tests used by Taylor and Quinney just as well as a perfectly isotropic tube. L. Nielsen, USA

787. **Wyatt, O. H., Transient creep in pure metals,** *Proc. phys. Soc. Lond.* (*B*) **66**, part 6, 402B, 459–480, June 1953.

A constant stress-testing machine of small inertia and with continuous strain-recording has been built. The loading was by air contained in metallic bellows whose wall stiffness was compensated by a "negative spring." Polycrystalline copper and aluminum have been investigated between −196 C and 140 C. At low temperatures the creep curves fitted $\epsilon = \alpha \log t + c_1$; at higher temperatures they fitted $\epsilon = \beta t^{1/3} + c_2$, called α and β creep. In an intermediate temperature range, the curves fitted $\epsilon = \alpha \log t + \beta t^{1/3} + c_3$. The results have been confirmed for cadmium, commercially pure aluminum, and aluminum with only a few grains per specimen. In a series of increment tests the stress was altered by small amounts at various times during a creep curve; in the α range only, the curves after the increments were similar to segments of the parent curve. The effect of testing a specimen at increasing stresses and different temperatures was also investigated; in the α range only, an equation of state, $F(\delta, \epsilon, d\epsilon/dt, T) = 0$, was obeyed. A theory of α creep is developed: An exhaustion theory is applied to a metal whose strain hardening is defined by a reference curve. The rise of activation stress during a creep curve and the slope of the reference curve are deduced from the increment and creep tests; and the slope agrees numerically with the stress-strain curve at −196 C. From an equation of state, values of the mean activation energy at a strain rate of 10^{-4} cm/cm/sec and the frequency of thermal fluctuations are obtained.

From author's summary by S. Edling, Sweden

788. **Mooney, M., A test of the theory of secondary viscoelastic stress,** *J. appl. Phys.* **24**, 6, 675–678, June 1953.

Mooney proves his theory regarding the stresses in liquids which transfer shear stresses during flow with the aid of experimental results presented by Garner, Nissan, and Wood [AMR **5**, Rev. 1079]. In their experiments, the liquid was between two circular disks, one placed over the other; the lower disk rotates with uniform speed, while the upper disk is at rest. Static pressure measurements could be made through holes in the upper disk, permitting the pressure distribution to be determined through momentum. The liquid near the upper disk is under simple shear stress. Mooney's theory requires a dependence between the magnitude of the shear stress and the elastic strain, and a further dependence between the shear stress and the two moduli of elasticity which enter into the theory of the magnitude of elastic strain.

In the case of linear dependence, the Newtonian theory of viscous fluids is valid. The experiments, however, could not be brought into accord with this. Other functional relations had to be found in order to make the experiments and theory agree; by making suitable assumptions, this goal was reached. It is pointed out that in order to finally clarify the nature of these functional relations, additional experiments are required.

L. Föppl, Germany

789. **Kaliciński, J., The influence of creep on concrete and reinforced-concrete structures** (in Polish), *Inżyn. Budown.* **10**, 1, 13–19, Jan. 1953.

Author gives useful data on final amplitudes and variations in the creep time and shrinkage of concrete as functions of variable parameters and makes a simplified analysis of the influence of these phenomena upon statically determinate and indeterminate structures. Especially considered are the change of the distribution of internal forces in reinforced columns, in hingeless and three-hinged arches, in continuous beams, and in frames (phenomenon of "adaptation"), etc. Author investigates the influence of nonuniform settling of the supports and temperature changes. Reviewer would like to draw attention to the objection involved by the use of fictitious, "effective," deformation modulus (as demonstrated, e.g., by F. Levi, AMR **5**, Rev. 1710).

S. Kaufman, Poland

Failure, Mechanics of Solid State

(See also Revs. 746, 794, 806, 940)

790. **Walker, P. B., Estimation of the fatigue life of a transport aircraft,** *J. roy. aero. Soc.* **57**, 514, 613–617, Oct. 1953.

A formula is developed for the safe life of an aircraft under normal operating conditions based on the fatigue failure of the wing. It is assumed that eventual failure will occur in the wing structure due to alternating loads produced by gust conditions encountered in normal flight.

Safe life is based on fatigue tests made on critical components of the wing structure under a steady load equal to the loading occurring in undisturbed level flight at the operating equivalent speed plus an alternating load which is taken 1.25 times the alternating loading superimposed by a gust of 8 ft/sec equivalent velocity at the operating equivalent speed. The alternating load is not taken less than 0.25 times the loading produced in undisturbed level flight. The nominal endurance N in cycles for each component is defined as two thirds of the logarithmic mean of the endurance of six specimens of the component tested under the standard loading conditions. The nominal endurance N of the wing as a whole is then the lowest nominal endurance of any of the components. The factors 1.25 and two thirds are chosen on the basis of experience, so that it is reasonably certain that failure will not occur in the specified number of cycles.

The safe or standard life of an aircraft is then most conveniently expressed in flying hours as $L = 2.5N/V$, where V is the operating speed in knots and 2.5 is a factor based on experience which depends upon the frequency of gusts encountered.

This factor requires modification for abnormal conditions, such as flight below 8000 ft, where turbulence is greater than at higher altitudes. W. O. Richmond, Canada

791. Roš, M., Wear and fatigue of steel rails (in French), *Rev. Métall.* **50**, 6, 388–409, June 1953.

This is an interesting and valuable article giving the results of extensive tests and their correlation with actual service results of rails used on the Swiss Federal Railways' St. Gothard line over a period of fifteen years.

Rails from five rolling mills of three types of steel—a high carbon-alloy steel of eutectoid structure and normal hardness, two single quality high carbon-alloy steels of normal hardness and eutectoid structure, and two medium carbon-alloy steels heat-treated to give a martensite structure—were included in the test program.

Details of the chemical composition, hardness before and after service, and fatigue limits before and after service, as a beam, and the wear measurements in cm^2 of the cross-sectional area, are all given with graphs, photographs of the rail cross sections, and microphotographs of the grain structure for all the test specimens.

Author's conclusions sum up very well the results of this very useful investigation: "The judicious and economic choice of rails with sufficient security from breakage can be determined technically to suit the traffic conditions which are presented in each case. It is possible today to make the choice on the basis of laboratory tests of the material and on the experience acquired by the trials on the actual track, especially the experience with the five kinds of rails analyzed in detail above, which are in production." A. O. White, USA

792. Smekal, A. G., Fracture analysis of brittle material under uni- or multiaxial stresses (in German), *Öst. Ing.-Arch.* **7**, 1, 49–70, 1953.

Rupture can only be explained in heterogeneous materials, and starts in spots where inhomogeneities are present. No rupture occurs in hardness tests on brittle materials such as silicates, corondum, boroncarbides if contact surface is smaller than $1\mu^2$, because the tested zone is more homogeneous. Statistical examination of fracture appearance obtained in bend tests on cylindrical silicate bars indicates that fracture does not start where strain is highest. Qualitative explanation is given.

Discrepancies between tensile and bending strength are explained; also influence of diameter and length of test piece. Ultrasonic measurements (Wallner lines) were used for measuring velocity of crack propagation. In first phase, velocity is rather small and depends on temperature, rate of loading, and test piece, but in second phase, velocity is very high and independent of temperature. Influence of time and temperature on tensile strength is due to velocity.

In plane state of stress, new type of rupture is mentioned, called lancet fracture. This rupture also starts in spots where inhomogeneities are present. These inhomogeneities are not explained. Dislocations are not mentioned.

W. Soete, Belgium

Material Test Techniques

(See also Revs. 746, 813)

793. Hardrath, H. F., Landers, C. B., and Utley, E. C., Jr., Axial load fatigue tests on notched and unnotched sheet specimens of 61S-T6 aluminum alloy, annealed 347 stainless steel and heat-treated 403 stainless steel, *NACA TN* 3017, 28 pp., Oct. 1953.

Axial-load fatigue tests at a stress ratio of zero were performed on notched and unnotched sheet specimens of 61S-T6 aluminum alloy and 347 and 403 stainless steels. Special emphasis was placed on tests at high stress levels which produce failures in small numbers of cycles. The stress-concentration factors effective in fatigue of notched specimens were found to be somewhat less than the theoretical elastic values at low stresses and were approximately equal to one at the ultimate strength. The minimum life to failure at stresses near the ultimate strength was drastically reduced with increasing stress-concentration factor.

From authors' summary by G. Gerard, USA

794. Vidal, G., Quick methods for the determination of the fatigue limit of metals and alloys (in French), *Rech. aéro.* no. 34, 49–54, July-Aug. 1953.

This is a survey of a number of the short-time tests that have been proposed for predicting the fatigue limit of a material. The survey is not entirely comprehensive; however, it contains interesting comments on several of the many tests that have been proposed. The general conclusion is that none of the short-time tests discussed can be expected to predict with certainty the fatigue limit as it is ordinarily defined in engineering use.

H. J. Grover, USA

795. Rao, C. V. J., and Sreenath, L. S., Design of low frequency fatigue testing machines, *J. Indian Inst. Sci.* **35**, 2, 87–92, 2 figs., Apr. 1953.

Paper describes method of designing two machines. The first consists of circular disk with eccentric mass rotated at about 100 rpm by electric motor. Forces produced by eccentric mass are transmitted to test specimen through piece in contact with rotating shaft, and produce both tensile and compressive stresses in specimen. The second machine utilizes a slight throw of eccentric on shaft, transmitted to the test specimen through spring, to produce intermittent tension only. Photographs, cross sections, and calculations are given. Value of such machines is chiefly for tests of aircraft structural members, since loads applied to these members result in low frequency fatigue rather than in shock or impact stresses because of inherent elasticity of aircraft structure. C. W. Smith, USA

796. Norris, G. M., Effect of mean stress on the fatigue strength of D.T.D. 364 round bars with and without transverse holes, *Aero. Res. Counc. Lond. curr. Pap.* no. 120, 8 pp., 8 figs., May 1952, published 1953.

Paper gives results of fatigue tests on round bars, with and without single transverse holes, of D.T.D. 364, an alloy whose characteristics are not given except for mechanical properties. Author concludes that at 2×10^6 cycle endurance, mean stress has greater influence on alternating stress for drilled than for plain bars. Also, fatigue stress-concentration factor was found to be 1.81, 2.28, and 2.31, respectively, for 0, 5, and 10 tons/$in.^2$ (British tons). Geometric stress-concentration factor for this hole in bar was experimentally determined to be 2.75. Fatigue stress-concentration factor was referred to alternating stress, not to total maximum stress. Reviewer notes that drilled bars had much smoother surface finish than plain bars, with definite evidence that roughness of latter reduced fatigue life. Hence, results are not strictly comparable. For equal smoothness, fatigue stress-concentration factor may well have approached geometric factor, particularly at higher mean stresses.

G. Winter, USA

797. Stewart, W. C., and Schreitz, W. G., Thermal shock and other comparison tests of austenitic and ferritic steels for main steam piping—a summary report, *Trans. ASME* **75**, 6, 1051–1067, Aug. 1953.

See AMR 6, Rev. 2537.

798. **Belyaev, N. M., Laboratory exercises in strength of materials [Laboratornie rabotí po soprotivleniyu materialov],** Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1951, 336 pp.

This is an unusually clear exposition of the elements of machines, methods, and instruments for the experimental verification of theory and formulas used in strength of materials. The explanations are given in great detail. The diagrams are good but the photographs are poor. The book is written as a student laboratory manual. The object and procedure of each exercise are outlined; the data to be collected and results to be obtained are indicated as headings in sample tables. Very few actual test data are presented. Much of the equipment and instrumentation described is of simple design.

The book is divided into three parts. Part I (chaps. 1–5, 229 pp.) deals with static test machines and methods. Part II (chaps. 6, 7, 38 pp.) deals with dynamic tests and machines. Part III (chaps. 8–10, 41 pp.) deals with specialized methods for stress investigation.

Chap. 1 describes hand- and motor-operated test machines for tension, compression, and bending, ranging from 1-ton to 200-ton capacity. Screw jacks and hydraulic jacks are used for loading. Manometers and pendulums are generally used for indicating load. Automatic recording of load-deflection data is done by string-operated drums and pencils or pens. Torsion test machines of 6 kg/m are also described.

Chap. 2 describes deformation and displacement measuring instruments. Detailed descriptions of vernier calipers, various forms of micrometers, mechanical and optical extensometers of base lengths 2 mm–1000 mm and of magnification 500–10,000 are given. The bonded resistance wire gage is also described.

Chap. 3 describes procedures for material tests in tension, compression, shear, torsion, 108° bend, high-temperature creep. Size and form effects are discussed. Welded joints and grooved specimens are included.

Chap. 4 describes standard hardness-testing procedures (Brinnell, Rockwell, Shore, scratch) plus some variations. Hardness of individual grains (microhardness) is obtained with a diamond pyramid under light loads (1 gm to some tens of grams).

Chap. 5 deals with miscellaneous experiments concerned with such topics as stress concentrations, coil and leaf spring deflections, principal stresses, bending of thin-wall open section beams, continuous beams, column stability, reciprocity relations, etc.

Chap. 6 discusses procedures for determining the effect of speed of loading on material properties. Impact testing and fatigue testing are given considerable attention.

Chap. 7 describes free- and forced-vibration tests on single-degree-of-freedom systems and the deflection in a horizontal beam produced by a dropping weight.

Chaps. 8–10 describe x-ray diffraction, photoelasticity, membrane analogy, and brittle-lacquer methods of stress analysis.

There are six short appendixes which present mechanical and chemical properties of materials, hardness conversion tables, and a table of energy absorption in Charpy impact tests.

W. W. Soroka, USA

Mechanical Properties of Specific Materials

(See also Revs. 701, 783, 787, 796, 942)

799. **Colbeck, E. W., Rait, J. R., and Ward, J. O., The design of creep-resisting steels,** *Engineering* **176,** 4577, 4578; 505–506, 537–540, Oct. 1953.

Authors summarize the physical property requirements for high-temperature materials and compare those properties for ferritic and austenitic materials. The effect of composition is reviewed for steels with varying chromium content in the matrix (especially 3 and 12%). They conclude that the important carbides are those containing vanadium, niobium, and titanium in a simple cubic structure and that good creep resistance will be obtained when the carbide-former-to-carbon ratio corresponds to the stoichiometric formation of the carbide.

M. J. Manjoine, USA

800. **Slunder, C. J., Hall, A. M., and Jackson, J. H., Laboratory investigation of superheater tubing materials in contact with synthetic combustion atmospheres at 1350 F,** *Trans. ASME* **75,** 6, 1015–1019, Aug. 1953.

Twelve commercially available alloys were tested in a corrosive environment that included combinations of two concentration levels of sulphur dioxide, carbon monoxide, and alkali-metal salts. A statistical analysis was made of the metal loss due to scaling and also of the depth of subsurface corrosion. A combination of these two analyses showed the alloys of the 25% Cr, 12% Ni and 25% Cr, 20% Ni types to be superior. AISI 304 also showed a high degree of resistance to both types of corrosion. The results of these controlled laboratory tests are in good agreement with results of field test installations which burn low-sulphur coal or natural gas. The conditions obtained in burning high-sulphur high-vanadium oil are not included in the laboratory tests.

These experiments have provided results of immediate practical importance; they have also shown that it might well be profitable to extend the range of alloys tested in order to provide some correlation between the resistance to corrosion and the components of the alloys. It is also suggested that a study of the chemical reactions involved in the corrosion process would be valuable.

Ione D. V. Faro, USA

801. **Hall, A. M., Douglass, D., and Jackson, J. H., Corrosion of mercury-boiler tubes during combustion of a heavy residual oil,** *Trans. ASME* **75,** 6, 1037–1049, Aug. 1953.

A study of reasons for and remedies against corrosion of tubes in boilers, particularly of the mercury type. Since these tubes normally operate at surface temperatures of from 1100 F to 1500 F, corrosion was severe due to low melting-point ashes from the fuel oil. A study was made by Battelle Memorial Institute in which two approaches were considered: (a) Reduction of corrosion by a protective coating on the tubes, and (b) by additives to the fuel. Protective coatings gave the most promise of success, and this paper gives in detail the test methods and the results. Of all the coatings tested, a 26% Cr-Fe alloy coating over the base tube metal (which was a Sicromo 5S steel) gave the most satisfactory results.

E. E. Sechler, USA

802. **Allen, N. P., Hopkins, B. E., and Tipler, H. R., Tensile and impact properties of high-purity iron-carbon and iron-carbon-manganese alloys of low carbon content,** *J. Iron Steel Inst. Lond.* **174,** part 2, 109–120, June 1953.

The tensile and impact properties of iron-carbon alloys of low carbon content and of some iron-carbon-manganese alloys at various temperatures spanning the tough-to-brittle transition have been measured for various heat-treatments above and below the A_1 point. It is shown that the rate of cooling from the austenitic region has a large effect on the properties obtained. A fast rate of cooling that favored retention of carbon in solution (but also decreased the grain size) generally gave improved proof stress and tensile strength, a higher cleavage strength at −196 C, and a lower temperature of transition from tough to brittle fracture in the Charpy impact test. On water-quenching, a good combination of tensile and impact properties was obtained at a carbon level of about 0.05%, but still further improvement was

obtained by adding manganese. Water-quenching iron-carbon alloys containing up to about 0.006% of carbon resulted in intergranular brittleness and a deterioration in properties. A slower rate of cooling that produced carbide films at grain boundaries and around areas of pearlite gave high impact transition temperatures. This is associated with the production of cracks in the carbide, which are considered to initiate cleavage of the ferrite at a temperature at which it should be ductile in the absence of the carbide films. The shape of the impact-value vs. temperature curve was modified when carbide films were present in the microstructure. Sufficient manganese prevented the formation of carbide films and gave a more or less sharp transition from tough to brittle fracture in impact. Some evidence is presented which suggests that the quench-aging of iron-carbon alloys, which involves a rise in impact transition temperature, is at least retarded by manganese. An extensometer that is not damaged when a tensile test piece breaks in a brittle manner at low temperatures is described. Electron-microscope pictures are presented to show the changes during aging.

From authors' summary by J. H. van der Veen, Holland

803. Hengstenberg, O., and Jäniche, W., The behavior of low-carbon basic Bessemer and open-hearth steels in strength and notch sensitivity tests (in German), *Stahl u. Eisen* **73,** 13, 828–838, June 1953.

Paper reports a very extensive wartime investigation in which 245 basic Bessemer and 44 open-hearth rimming low-carbon steels were compared in tension and impact tests. Nitrogen content of the basic Bessemer steels varied between 0.005 and 0.027%, which means that the German types of improved basic Bessemer steels were included in the investigation. In tension tests, some systematic differences of probably minor importance were found. The most marked difference was that the decrease of elongation after strain-aging was higher for the open-hearth steels, whereas the decrease of reduction of area was higher for the basic Bessemer steels. More important differences were found in impact testing, especially after strain-aging. Open-hearth steels were definitely better, even when compared with the improved basic Bessemer steels which had the same N and P contents as open-hearth steel. The decrease in impact energy by strain-aging was divided into two parts, viz., the decrease due to natural aging after straining alone and the extra decrease after additional heat-treatment (1/2 hr at 250 C). It was found that especially the first part was greatest for basic Bessemer steels. An explanation for the superiority of open-hearth steels when compared with basic Bessemer of the same N and P content could not be found. J. H. van der Veen, Holland

804. Springorum, F. A., Speith, K. G., and Oelsen, W., On the fining of Thomas pig iron with pure oxygen (in German), *Stahl u. Eisen* **73,** 1, 6–22, Jan. 1953.

In a 3-t-converter, pure oxygen was blown on the surface of iron. In this way it was shown that it is possible to make steel equivalent to open-hearth quality even from pig iron with about 2% P. If iron ore was added in the first minutes of the blowing, the dephosphorization of the iron was finished earlier than with the usual basic Bessemer process and the steel contained only very little nitrogen. F. Wever, Germany

805. Collaud, A., Investigation on the toughness of gray cast iron (in French), *von Roll Mitteilungen* **11,** 3/4, 93–104, July-Dec. 1952.

Impact tests on cast iron must be carefully made to take into account the kinetic energy of the fractured specimen. This paper reports tests conducted on unnotched bars in which only enough energy is applied to fracture the specimen, with no excess to impart any velocity to the broken pieces.

Curves of the data from many such tests on gray iron specimens show that the toughness varies directly with (1) modulus of elasticity, (2) Brinnell hardness, and (3) resistance to static load.

C. F. Peck, Jr., USA

806. Wållgren, G., Direct fatigue tests with tensile and compressive mean stresses on 24S-T aluminium plain specimens and specimens notched by a drilled hole, *Flygtekn. Försöksanst. Medd.* no. 48, 29 pp., 1953.

Test results are reported on the fatigue strength of an aluminum alloy 24S-T under mean stresses ranging from 27 kg/mm² in tension to 40 kg/mm² in compression. Cylindrical specimens both with and without notches were tested. The results show that fatigue strength under compressive load is comparatively higher than under tensile load.

A discussion is given on the fatigue-strength reduction factor *Kf*, which is defined as a ratio of the fatigue strength of unnotched specimen to that of notched one at a selected number of cycles of stressing. For the material tested, it was found that *Kf* remained fairly constant for various mean stresses if the ratio of the maximum stress to the minimum stress in a cycle of stressing was taken as a basis for comparison. L.-W. Hu, USA

807. Heimerl, G. H., and Hughes, P. J., Structural efficiencies of various aluminum, titanium, and steel alloys at elevated temperatures, *NACA TN* 2975, 16 pp., July 1953.

Efficient temperature ranges are indicated for two high-strength aluminum alloys, two titanium alloys, and three steels for some short-time compression-loading applications at elevated temperatures. Only the effects of constant temperatures and short exposure to temperature are considered, and creep is assumed not to be a factor. The structural-efficiency analysis is based upon preliminary results of short-time elevated-temperature compressive stress-strain tests of the materials. The analysis covers strength under uniaxial compression, elastic stiffness, column buckling, and the buckling of long plates in compression or in shear. From authors' summary

808. Bordoni, G., Elastic and anelastic behavior of some metals at very low temperatures (in Italian), *Ric. sci.* **23,** 7, 1193–1202, July 1953.

Vibration frequency and damping have been measured as a function of temperature in the range 4.5 K–300 K for lead, copper, aluminum, and silver rods. Damping has been found to reach a maximum near 1/3 of Debye temperature, owing to a new relaxation effect. Near the absolute zero both damping and frequency changes vanish as a high power of temperature.

From author's summary by F. K. G. Odqvist, Sweden

809. Kluz, T., Rising resistance of vibrated concrete of low water-cement ratio (in Polish), *Inżyn. Budown.* **9, 12,** 401–405, Dec. 1952.

Author states that vibrated, high-resistance concretes used, for example, for prestressed constructions, reach much greater resistance in the first days of hardening as compared to the values after 28 days' r sistance than do hitherto generally tested plastic concretes, densified by hand, of water-cement ratio above 0.4 (generally 0.5–0.8).

Under author's direction, cylindrical specimens, 16-cm diam and 16 cm high, of Portland cement concrete, broken aggregate, vibrated, with water-cement ratio 0.35, have shown the following increase of strength: $R_{28}:R_3$ = about 1.9. This means that, after three days, the concrete has reached half of its final strength;

$R_{28}:R_7$ = about 1.3. Author proposes the following formulas for vibrated concrete with water-cement ratio 0.3–0.4: $R_{28} = R_3 + 13.75(R_3)^{1/2}$; $R_{28} = R_7 + 5.17(R_7)^{1/2}$. These are in contrast to hitherto applied formulas for plastic concretes with water-cement ratio above 0.4; e.g., according to Slater's formula, $R_{28} = R_7 + 8(R_7)^{1/2}$. J. Nechay, Poland

810. **Hisada, T., Study on wood members subjected to combined compressive and bending stresses,** *Bldg. Res. Inst. Rep.* no. 1, Japanese Ministry of Construction, 28 pp., May 1953.

Theory and experiments are described on the behavior of 154 solid 4.5 by 9-in. wood (Sugi) columns subjected to centric and/or eccentric loads. The results of the investigation led to the conclusion that the conventional formula used in Japan can be applied without any change.

Complete test data are presented in both tabular and diagrammatic form. E. George Stern, USA

811. **Sauer, J. A., and Hsiao, C. C., Stress-crazing of plastics,** *Trans. ASME* **75,** 5, 895–901, July 1953.

See AMR 6, Rev. 2250.

812. **Hood, B. G., Investigation of the frictional properties of textile fibers under variable fiber stress,** *Textile Res. J.* **23,** 7, 495–505, July 1953.

A means for investigating interfiber friction has been developed. The resulting instrument is based on the fiber twist principle; its usefulness as a tool of investigation in the study of interfiber friction is shown. Its main virtues are its broad adaptabilty and simplicity and its realistic consideration of the nature of interfiber contact in textile materials. The presence of fiber crimp was found to increase greatly the frictional resistance of the fibers.

Evidence was found that the coefficient of friction may be dependent on both the real and apparent areas of contact for wool, hair fibers possessing some form of scales, and cotton. Colloidal silica dispersions were found to increase greatly the clinging power of cotton and give better control over cotton fiber friction.

It was shown that the shape of the frictional characteristic curve of a particular fiber may be definitely correlated with its behavior during drafting—i.e., the behavior of the fibers during drafting or spinning may be more dependent on the relationship between the values of the friction of a particular fiber at different stresses than on the value of the friction at any particular stress.

From author's summary

813. **Kärrholm, E. Marianne, and Schröder, B., Bending modulus of fibers measured with the resonance frequency method,** *Textile Res. J.* **23,** 4, 207–224, Apr. 1953.

The dynamic elastic modulus of filaments in bending was measured by observing the resonant frequency of transverse vibration for filaments driven at a clamped end and free at the other. The effect of air damping and of internal friction on the resonant frequency was taken into account. Measurements were made on steel, viscose, nylon, human hair, and wool. The dynamic elastic modulus in stretching also was obtained for steel and for viscose. The bending modulus was found to be more than $1\frac{1}{2}$ times as great as the stretching modulus. This disparity is attributed to the inhomogeneity of elastic properties across the section of the filament, the outer portions being stiffer.

Reviewer believes that the analysis of air damping is not at all rigorous, but that the effect of damping is so small that any errors are unimportant. The experimental work and data reduction have been done carefully. The paper is marred by lack of abstract, some incorrect terminology, ambiguous notation, and incomplete references. D. J. Montgomery, USA

814. **Rouse, P. E., Jr., and Sittel, K., Viscoelastic properties of dilute polymer solutions,** *J. appl. Phys.* **24,** 6, 690–696, June 1953.

Viscoelastic properties of dilute solutions of chain polymers were measured at frequencies from 200 cps to 60 kc. Comparison is made with theoretical curves based on steady-flow viscosities of solution and solvent, molecular weight, and concentration of polymer and absolute temperature. Theory is found to be good first approximation for viscoelastic properties of solutions studied.

Results imply that up to 60 kc, viscoelastic properties of dilute solutions of polystyrene and polyisobutylene are caused by thermal motions of segments of polymer molecules which produce changes in configuration of molecules. Configuration changes have relaxation time dependency which is function of weight of polymer, concentration, type, and viscosity of solvent.

Extensive review of prior work is included as well as thorough appraisal of new techniques and theory developed.

F. J. Mehringer, USA

815. **Grandine, L. D., Jr., and Ferry, J. D., Dynamic mechanical properties of the system polystyrene-decalin,** *J. appl. Phys.* **24,** 6, 679–685, June 1953.

The dynamic rigidities and viscosities of polystyrene and solutions of polystyrene in decalin have been measured by three experimental methods over ranges of temperature from 115 to 133 C and of frequency from 30 to 2800 cps for polystyrene, and from −5 to 50 C and 30 to 2000 cps for solutions of 10 to 62% concentration. The data for the undiluted polymer when reduced to a standard temperature, and the data for the solutions when reduced to a reference state of unit density and viscosity at a standard temperature, each provide single composite curves for dynamic rigidity and viscosity. The distribution function of relaxation times for the solutions shows three characteristic regions, and the distribution function for the undiluted polymer lies near that for the solutions. Apparent energies of activation for relaxation agree with those for viscous flow obtained by Fox and Flory.

From authors' summary by W. N. Findley, USA

Mechanics of Forming and Cutting

816. **Winkler, O., The technical principles of melting and casting under conditions of a high vacuum** (in German), *Stahl u. Eisen* **73,** 20, 1261–1268, Sept. 1953.

Equipment for making steel ingots under pressures < 0.1 mm Hg is described, including resistance vs. induction furnaces, crucibles and molds, vacuum pumps, valves, and seals. Principles of manipulation and control are given.

Metallurgical aspects of vacuum remelting of steel (degasation, loss of Mn) are discussed. Author cites applications and scope of the process. N. H. Polakowski, England

817. **Favre, A. E., Light-alloy forging—design and production problems as related to heavy-press operations,** *Mech. Engng., N.Y.* **75,** 9, 693–697, 718, Sept. 1953.

818. **Skow, N. A., Metal-clad laminates used in printed circuitry,** *Mech. Engng., N.Y.* **75,** 9, 709–711, 714, Sept. 1953.

819. **Kastan, H., Panel extrusions in aircraft structures,** *Mech. Engng., N.Y.* **75,** 9, 715–718, Sept. 1953.

820. **Gilbert, W. W., Boston, O. W., and Siekmann, H. J., Power required by carbide-tipped face-milling cutters,** *Trans. ASME* **75,** 6, 1087–1100, Aug. 1953.

See AMR 6, Rev. 2253.

821. **Hahn, R. S., Metal-cutting chatter and its elimination,** *Trans. ASME* **75,** 6, 1073–1078, Aug. 1953.
See AMR **6,** Rev. 3097.

822. **Oathout, J. D., Howell, W. C., Jr., Hamer, J. P., and Leland, H. L., A lathe test for the evaluation of cutting fluids,** *Trans. ASME* **75,** 6, 1081–1085, Aug. 1953.
See AMR **6,** Rev. 3105.

823. **Letner, H. R., and Snyder, H. J., Grinding and lapping stresses in manganese oil-hardening tool steel,** *Trans. ASME* **75,** 5, 873–880, July 1953.
See AMR **6,** Rev. 2252.

824. **Leyensetter, W., Observations on tool life when milling cast-iron housings with sintered carbide-tipped milling cutters** (in German), *Werkstatt u. Betrieb* **85,** 10, 515–520, Oct. 1952.

The tool life of milling cutters can be considered from several points of view, but author uses the general expression "tool life." He admits that this is dependent upon such factors as length of path, milled surface, and milled chip volume. Criteria for tool life include the following: Wear of cutting tool, reduction in surface finish (exceeding a permissible allowance), exceeding the maximum value of the cutting force or cutting capacity of machine, change of chip formation, increased heating of workpiece, increased noise and vibration. From this it follows that one should speak not of a single tool life but of a tool-life range and, according to the rigidity of the machine, one should keep at the upper or lower limit of the range for a distinct cutting speed.

American investigations, by M. Kronenberg in particular, are compared with recent investigations at a motor manufacturer (Daimler-Benz AG). In the American test, the tool life drops below a cutting speed of 90 m/min (270 fpm). The German observations show an increase in tool life down to a cutting speed of 38 m/min (118 fpm), probably due to a smaller feed per tooth. Feed according to American tests is certainly much higher than that used in German practice, partly because the machine or workpiece is not rigid enough. No influence of the impact of the tooth on the workpiece (Auftreffbedingungen) on tool life can be observed. P. Grodzinski, England

Hydraulics; Cavitation; Transport

(See also Revs. 775, 908)

825. **Westervelt, P. J., Hydrodynamic flow and Oseen's approximation,** *J. acoust. Soc. Amer.* **25,** 5, 951–953, Sept. 1953.

The hydrodynamic flow in the neighborhood of an obstacle immersed in a streaming and oscillating incompressible fluid is considered, the particle displacement amplitude being assumed small relative to the characteristic linear dimension of the immersed body. It is shown that the Oseen approximation leads to the value zero for the vector velocity potential specifying the steady streaming velocity. Thus, if a solution of the streaming problem is to be found, the terms nonlinear in the first-order velocity of fluid must be retained. R. Heller, USA

826. **Thomas, L. H., The stability of plane Poiseuille flow,** *Phys. Rev.* (2) **91,** 4, 780–783, Aug. 1953.

The Sommerfeld-Orr equation for plane disturbance of plane Poiseuille flow has been treated by a numerical method. The derivatives in the equation are expressed in terms of central differences, and the resulting sets of algebraic equations for various values of R and the wave length $2\pi/\alpha$ (expressed in half the channel width) of the disturbance were solved by direct elimination, using an IBM electronic computer. The stability limit was then determined by interpolation. It was located at $R = 5780$, $\alpha = 1.026$, in good agreement with Lin's approximate result $R = 5300$, $\alpha = 1$, obtained by using asymptotic series.

L. J. F. Broer, Holland

827. **Engelund, F., and Munch-Petersen, J., Steady flow in contracted and expanded rectangular channels. Some considerations concerning the shape of the water surface,** *Houille blanche* **8,** 4, 464–474 (French text, 475–481), Aug.-Sept. 1953.

A theoretical study of wave forms in channel transitions is developed and compared with newly reported experiments and with the work of Ippen and others.

Frictionless, irrotational flow is assumed and a solution found that satisfies the basic equations and boundary conditions at walls and the free surface, based on a linearized theory. The resulting equations are in good agreement with new and previous experiments except for effects of friction, which are neglected.

V. L. Streeter, USA

828. **Guevel, P., Application of the Schwartz Cristoffel transformation for the study of underground outlets** (in French), *C. R. Acad. Sci. Paris.* **237,** 12, 597–599, Sept. 1953.

Author studies a dam comprising a sheet piling and lying on permeable ground limited by an impermeable horizontal substratum. By means of an analytical transformation, he designs a corresponding simpler profile consisting of a sheet piling driven in a permeable medium.

The method affords the possibility of dealing with the case of a dam base presenting, or not presenting, a difference in level, protected by a sheet piling either placed or driven.

L. Escande, France

829. **Boreli, M., On the rigorous solution of a two-dimensional flow problem of underground water** (in French), *C. R. Acad. Sci. Paris* **237,** 2, 132–135, July 1953.

Study of steady two-dimensional potential flow of underground water. Case of drain upstream of impervious cores in a dike was analyzed in a previous note [AMR **6,** Rev. 2259]. Effect of moving core to infinite distance upstream is discussed.

A. L. Jorissen, USA

830. **Howland, W. E., Design of perforated pipe for uniformity of discharge,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 687–701, 1953.

Equal distribution of discharge along a perforated pipe is desirable in certain applications. Economical design requires that the holes be varied either in spacing or in size. Author presents a method of calculating the required variation, based on theoretical pressure distribution in the pipe and experimentally determined coefficients of discharge for orifices. Results of latter tests, essential to use of method, are not fully presented. Limited range of experimental checks on single design tends to verify method. Reduction of up to two thirds in cost of filter-pipe laterals is claimed possible in use of method.

W. De Lapp, USA

831. **Irmay, S., Saturated steady flow in non-homogeneous media and its applications to earth embankments, wells, drains,** Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, in 3 vols., vol. II, 259–263.

Author formulates general problem, $\nabla^2 E = \nabla \ln w \cdot \nabla E$, after Boussinesq, where E is total energy $[L]$ of flow and w is hydraulic resistivity $[L^{-1}T]$ (a second-order tensor for nonisotropic media). He then obtains relations in one-dimensional steady confined

flow, especially for pressure variations, and presents illustrative qualitative field data. A table of mean resistivities, $\bar{w} = \left(\int_0^L w ds\right)/L$, is given for several $w(s)$. For unconfined flow through vertical layers to ditches, author uses Dupuit's hypothesis to devise usual formulas but with $\bar{w}$ appearing. For unconfined flow to a well through layers having vertical rotational symmetry, author calculates $(H^2 - z_0^2)\pi/Q = {}_r\int^L (w/x)dx$, where $H - z_0$ is drawdown, Q is rate of discharge, r is well radius, and L is radius of drawdown cone; this does not reduce to the Dupuit formula unless w = constant. F. T. Rogers, Jr., USA

832. **Tanaka, K., On the quasi-steady flow in the open channel. (The theoretical analysis of flood routing),** *Technol. Rep. Osaka Univ.* **2,** 181–194, Oct. 1952.

Author starts with the equation of unsteady flow with friction and the continuity equation. Solutions of the second of these in the form of nondispersive waves are then used for short reaches of channel and modified to fit the unsteady-flow equation. It is necessary to ignore certain small terms in the equations even in this stepwise process. Reviewer feels that procedure is a good approximation but believes experimental verification is also needed since the dropping of small terms in the differential equation does not assure a good approximation to the solution.
D. F. Gunder, USA

833. **Lipscome, E. B., The technique and application of hydraulic model studies involving movable beds,** Proc. Fifth Hydraulics Conf., June 9–11, 1952; State Univ. of Iowa, *Studies in Engng. Bull.* 34, 47–65, 1953.

Paper points out importance of model studies as showing the way to improvements which will reduce the large yearly cost of waterway maintenance. Model work done in the Vicksburg laboratory on the harbor development at Memphis, Miss., is described. A second problem involved unstable caving banks. A technique was finally developed for reproducing the erosion of such banks and the accompanying deposition. A third study involved a model of meandering streams.

Although movable bed models date back to Fargue's 1875 studies, no references are made to earlier papers or to the extensive theoretical work in this field. In fact, the author infers that all theoretical discussion of the problem is useless and that "the verification of a model of this sort is simply a cut-and-try process."

Reviewer believes that this cannot be permanently true and that ultimately a satisfactory theory for these kinds of models will be developed. Carlson, of the Bureau of Reclamation laboratory at Denver, in his discussion of this paper suggested using the ratio of the settling velocities between model and prototype sediment as a scale criterion. R. W. Powell, USA

834. **Harasima, A., Statistical mechanics of surface tension,** *J. phys. Soc. Japan* **8,** 3, 343–347, May-June 1953.

835. **Grisodub, Yu. N., On the calculation of the propagation of harmonic disturbances in hydraulic piping systems in series and in parallel** (in Russian), *Zh. tekh. Fiz.* **21,** 5, 564–572, May 1951.

On the basis of electroacoustic and impedance-and-four-pole-theory, formulas for calculation of the harmonic vibration in a hydraulic piping system are obtained. The calculations for the following special cases are carried out: (a) Piping with "stepped" diameter; (b) piping with branches; (c) combination of (a) and (b).

The results of calculation are compared with the results of a test series. M. Strscheletzky, Germany

836. **Gemant, A., Tracer diffusion in the ground in radioactive leak location,** *J. appl. Phys.* **24,** 1, 93–95, Jan. 1953.

The diffusion in the ground of a radioactive tracer gas, used for locating leaks in buried pipes, has been calculated and the results are presented in the form of graphs. It is shown how the information can be used to obtain the amount of radioactivity needed in a test for both beta emitters (C-14 in carbon monoxide) and gamma emitters (Br-82 in methyl bromide).
From author's summary

837. **Marzolo, F., Report on scientific activity in hydraulics during the year 1952** (in Italian), *Ric. sci.* **23,** 8, 1170–1173, July 1953.

This is a report on the scientific activity, on the model test research, and on the publications made by the Centro Veneto di Ricerche Idrauliche del Consiglio Nazionale delle Ricerche during the year 1952 regarding researches on the standard flow nozzles, stability of regulation of hydroelectric power plants, shape of the sections of river channels, pitot sounding probe, movement of bed load in a forked channel, control of the efficiency of settling basins, self-regulating intake works, and circular sharp-crested weirs.
From author's summary

838. **Scimemi, E., Report on scientific activity in hydraulics during 1950–1951** (in Italian), *Ric. sci.* **23,** 7, 1165–1169, July 1953.

A report on the scientific activity, the model test research, and on the publications that the Centro Veneto di Ricerche Idrauliche del Consiglio Nazionale delle Ricerche made during the year 1950–1951 regarding water hammer, aeration of the Bazin weir, diversion of a flood wave from the river Adige, researches on uniform motion in pipes, stability of regulation of hydroelectric power plants, movement of bed load in a forked channel, and control of the efficiency of settling basins. From author's summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 672, 699, 844, 863, 890, 891, 893, 900, 914)

839. **Escande, L., Drag of a flat plate with a wake** (in French), *C. R. Acad. Sci. Paris* **237,** 12, 591–593, Sept. 1953.

The drag of a plate spanning a wind tunnel and normal to the flow direction is investigated. Perforations in the plate or cylinders protruding from the wake reduce the drag to that for plates of moderate aspect ratio. G. E. Nitzberg, USA

840. **Cummins, W. E., The forces and moments acting on a body moving in an arbitrary potential stream,** *David W. Taylor Mod. Basin Rep.* 780, 57 pp., June 1953.

The force and moment on a body placed in an arbitrary steady potential flow were found by Lagally when the body can be represented by a system of singularities interior to the surface of the body. They were found to be simple functions of the strengths of the singularities and the character of the undisturbed stream in the neighborhood of the singularities. In the present paper, this result is rederived and extended to the case in which the body is subject to an arbitrary nonsteady motion (including rotation) in a stream which is changing with time. The force and moment are found to be the "Lagally force and moment" plus additional components. These additional components are given for the force as simple functions of the singularities used in establishing the boundary condition and of the motion of the body, but an integration over the surface of the body is required for the moment. From author's summary by M. D. Friedman, USA

841. Friedrich, C. M., and Forstall, W., Jr., A numerical method for computing the diffusion rate of coaxial jets, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 635–649, 1953.

Paper concerns discharge of round jet into moving uniform medium. Only incompressible fluid is considered and pressure is taken as constant throughout. Numerical method is used to solve momentum and continuity equations. These are applied as finite difference equations to regions having the shape of toroids of rectangular cross section. By starting from known conditions inside jet before mixing, these approximate equations can be solved step by step. A numerical example shows fair agreement with experimental results. J. V. Foa, USA

842. Galle, K. R., and Binder, R. C., Two-dimensional flow through a diffuser with an exit length, *J. appl. Mech.* 20, 3, 390–392, Sept. 1953.

For incompressible flow, the velocity distributions and pressure-rise characteristics were determined in plane-wall two-dimensional diffusers. These characteristics were determined as a function of distance from the inlet both with and without a downstream conduit. Total divergence angles were 8.14° and 10.20°. Criteria for separation are presented. The plotted data are indicative of a carefully conducted experiment. M. R. Carstens, USA

843. Kofskey, M. G., Allen, H. W., and Herzig, H. Z., Comparison of secondary flows and boundary-layer accumulations in several turbine nozzles, *NACA TN* 2989, 58 pp., Aug. 1953.

An investigation was made of losses and secondary flows in three different turbine-nozzle configurations in annular cascades. Appreciable outer-shroud loss cores (passage vortexes) were found to exist at the discharge of blades which had thickened suction surface boundary layers near the outer shroud. Blade designs having thinner boundary layers did not show such outer-shroud loss cores, but indicated greater inward radial flow of low momentum air in the blade wake which resulted in greater contribution to inner-shroud loss regions.

The blade wake was a combination of profile loss and low momentum air from the outer shroud, and the magnitude of the wake loss is to this extent an indication of the presence or absence of radial flow. At a higher Mach number, shock-boundary-layer thickening on the blade suction surfaces provided an additional radial flow path for low momentum air, which resulted in large inner-shroud loss regions accompanied by large deviations from design values of discharge angle. From authors' summary

Compressible Flow, Gas Dynamics

See also Revs. 672, 869, 871, 875, 880, 885, 889, 892, 899, 900, 905)

844. Shapiro, A. H., The dynamics and thermodynamics of compressible fluid flow, Vol. I, New York, The Ronald Press Co., 1953, xiii + 647 pp. $16.

This is the first comprehensive book of its kind and is a welcome addition to the literature on the subject. The first volume consists of five parts and an appendix. Part one gives background material, such as foundations of fluid dynamics, thermodynamics, and introductory concepts to compressible flow. The concept of continuum is discussed and the density, velocity, and pressure at a point defined. Viscosity and shear stresses are introduced. System and control volume are explained. The principles of conservation of mass, momentum, and the theorem of moment of momentum are interpreted physically and their mathematical formulation is given. The zero-th, first, and second laws of thermodynamics are discussed and the two latter ones formulated for a control volume. The equations of state and changes of state are given for a perfect gas. The velocity of propagation of a plane pressure pulse, the velocity of sound in a perfect gas, and the physical differences between incompressible flows are treated and illustrated. Similarity is the next topic. Finally, optical methods of investigation, such as interferometry, schlieren and shadograph measurements, and the instruments used are discussed in detail.

Part two deals with one-dimensional flows. The necessary assumptions are explained for the treatment of a certain flow phenomenon as one-dimensional. The general features of isentropic and adiabatic flows are discussed. Choking in isentropic flow and nozzles is analyzed. The deviations from perfect gas laws are treated in detail. Normal shock waves, normal shock in a perfect gas, and weak shock waves follow next. The formation of shock waves is explained and analyzed. Normal shocks in ducts, nozzles, and supersonic diffusers are treated as well as supersonic inlets. Flow in constant-area ducts with friction, i.e., the adiabatic, constant-area flow is the next topic. Also, choking due to friction is discussed as well as the performance of long ducts at various pressure ratios and under isothermal conditions. Next, flow in ducts with heating and cooling is treated in detail. Choking and the formation of shock waves are discussed. Finally, the generalized one-dimensional continuous flow is analyzed, where area change, wall friction, drag of internal bodies, external heat exchange, chemical reactions, change of phase, mixing of gases, and changes in molecular weight are taken into account. The well-known tables of "influence coefficients" are included which were developed by A. H. Shapiro and W. R. Hawthorne in 1947.

Part three is an introduction to two- and three-dimensional flows. The equations of motion for steady, irrotational flows are developed. The velocity potential and stream function are introduced and the equations of motion transformed, using first the velocity potential and then the stream function as the dependent variable.

Part four deals with subsonic flows. Two-dimensional flows are treated by the method of small perturbations. The various similarity rules are given and discussed. Next, the hodograph method is presented for two-dimensional flows. The Rayleigh-Janzen, the Prandtl-Glauert, and the relaxation methods are presented and applications are given. Finally, the three-dimensional, subsonic flows are treated for bodies of revolution, spheres, and wings of finite span.

Part five treats supersonic flows. Two-dimensional, supersonic flows are analyzed by the method of small perturbations. Physical discussion of the flow is given first; then supersonic airfoils, reflection and intersection of waves are treated. The method of characteristics for two-dimensional supersonic flows is developed and applied. The advantages and disadvantages of graphical and various numerical methods are discussed. Applications of the methods include treatment of the thin profile, underexpanded nozzle, supersonic wind tunnel, turbine and compressor cascades, supersonic inlets, and supersonic wind-tunnel design. The numerical and graphical methods for the analysis of oblique shocks are given next. Shock reflection and interaction are treated. Examples are given. Two-dimensional profiles are treated by the various methods.

Appendix A develops the theory of characteristics. Appendix B contains tables of compressible-flow functions. These are: Properties of the standard atmosphere; Isentropic flow; Normal shock; Frictional, adiabatic, constant-area flow (Fanno line); Frictionless, constant-area flow with change in stagnation temperature (Rayleigh line); Influence coefficients; Hodograph

characteristic functions for two-dimensional, isentropic, supersonic flow; Coefficients for second-order theory of two-dimensional supersonic flow.

Problems are given at the end of each of the sixteen chapters,

In reviewing, it is difficult to do justice to a book containing such a large amount of material. Undoubtedly, it will be very useful for two types of users. For the student it will be an excellent guide in learning the subject. For the practicing engineer it will be of great value as a reference book. However, any book covering the broad field of thermodynamics of compressible flows must be restricted to limited presentation of some of the topics. The student, and in some cases the practicing engineer also, will have to consult the references. The reviewer feels that more references should have been included to aid the users of the book. There are a few remarks in order regarding some of the topics. Although the limitations of the continuum principle (macroscopic approach) are pointed out, a book of such extent should include the basic principles of kinetic theory and statistical mechanics (microscopic approach). The energy equation is not given in its general (three-dimensional) differential form, but it is quite possible that it will be included in the second volume. To do complete justice to the book, the two volumes should be reviewed together. Final judgment can only be made when the second volume is available.

T. P. Torda, USA

845. **Bernard, J.-J., Application of polynomial distributions to the determination of thickness of shock wave** (in French), *C. R. Acad. Sci. Paris* **237,** 2, 130–132, July 1953.

Author proposes to solve the kinetic problem connected with a shock wave by introducing a molecular velocity distribution consisting of a sum of simple Maxwellian terms, each term having three parameters (corresponding to number of molecules, mean kinetic energy, and mean velocity, respectively, for the group of molecules described by that term), which parameters are functions of the coordinate x. The first and the last terms of the sum refer to the initial and end states of the gas, respectively. The Maxwell-Boltzmann equation for the transfer of functions of the molecular velocities is used to derive a sufficient number of differential equations for the parameters. It is found that the sum must consist at least of five terms (with less, one always comes back to the case of two terms, treated by Mott-Smith, AMR **5,** Rev. 784). A few results are indicated qualitatively. Reference is made to a paper in *Rech. aéro.* [AMR **6,** Rev. 3813].

J. M. Burgers, Holland

846. **Guderley, G., On the presence of shocks in mixed subsonic-supersonic flow patterns,** Advances in appl. Mech. **III,** 145–184, 1953. [Academic Press, Inc., N. Y.]

A theoretical investigation is directed toward explaining why shocks almost always occur when supersonic regions are embedded in a subsonic flow. Mathematically, it is shown by analogy to Tricomi's boundary-value problem that, in general, there do not exist solutions of the boundary-value problem associated with mixed subsonic-supersonic (i.e., elliptic-hyperbolic) potential flows. Physically, the particular solutions whose presence indicates the impossibility of a potential flow are interpreted as corresponding to a wavy flow in the physical plane.

A. H. Shapiro, USA

847. **Benedikt, E. T., Open-nose body of revolution of minimum drag at small supersonic speeds,** *J. aero. Sci.* **20,** 10, 720–722, Oct. 1953.

The body shape of minimum drag for given length, entrance diameter, and exit diameter is determined from the slender-body drag equation. Consequently, the results are a simple extension of the minimum problems considered by several investigators for bodies of revolution.

E. B. Klunker, USA

848. **Flax, A. H., Integral relations in the linearized theory of wing-body interference,** *J. aero. Sci.* **20,** 7, 483–490, July 1953.

Reverse-flow theorems, based on linearized compressible flow theory, are applied to the case of a wing mounted on a cylindrical body of any cross-sectional shape. General relations between integrated lifts and moments on the wing, the body, and the combination are derived. Specific results, of particular interest for calculation purposes, include: (a) The lift distribution on the wing-body combination in reverse flow is the influence function for the lift of the combination; (b) the influence function for rolling moment is the lift distribution over the combination rolling at constant angular velocity in reverse flow; (c) the lift induced on the wings by a unit body angle of attack is equal to the lift induced on the body by a unit wing angle of attack in reverse flow.

M. A. Heaslet, USA

849. **Woods, L. C., The application of the polygon method to the calculation of the compressible subsonic flow round two-dimensional profiles,** *Aero. Res. Counc. Lond. curr. Pap.* no. 115, 31 pp., June 1952, published 1953.

Author solves numerically by his polygon method an approximate integral equation (based on von Kármán's approximation that $m = (1 - M^2)^{1/2}\rho_0/\rho = m_\infty$) for the boundary velocity on an airfoil in compressible flow. This method replaces airfoil boundary by small arcs on which product of radius of curvature and velocity is constant. Comparison with experimental results for RAE 104 airfoil at $M_\infty = 0.7$ shows reasonable agreement at same C_L, except near the nose. Reviewer notes that no a priori estimates of error are given.

H. C. Levey, Australia

850. **Yoshirara, H., The flow over a cone cylinder body at Mach number one,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 287–301, 1953.

The flow pattern for zero angle of attack is computed using relaxation methods in the subsonic region and method of characteristics in the supersonic region. The approximate position of the dividing sonic line and the starting values for the relaxation method are first obtained from the author's solution for a cusped nose body [*USAF TR* no. 5797, Sept. 1949] with appropriate modifications near the body. By process of iteration, involving the matching of the subsonic and supersonic solutions, the correct sonic line is determined, this differing only slightly from the initial guess. Results indicate that the transonic similarity law based upon slender-body theory can be extended to cover cone cylinder bodies of practical slenderness ratios.

F. A. Goldsworthy, England

851. **Kawamura, T., A note on the detached shock wave in front of a body,** *J. Japan Soc. appl. Mech.* **5,** 30/31, 162–165, Dec. 1952/Jan. 1953.

In a previous paper [AMR **6,** Rev. 1318], author expanded equation for detached shock in front of body of revolution in terms of an even power series. He approximated flow close to axis by parabolic shock wave. In present paper, he makes approximation for a flow near axis of symmetry as a hyperbola, as suggested by the flow at infinity over an obstacle of finite size. With this approximation, author calculates position of detached shock wave and applies results to the case of a circular cylinder in two-dimensional flow and a sphere in three-dimensional flow. Tabulated numerical results indicate theory of present paper to be slightly better than previous paper in prediction of position of

detached shock, although difference between the two approximate theories is much less than difference between either theory and experimental results quoted in the paper.

H. G. Stever, USA

852. Barish, D. T., and Guderley, G., Asymptotic forms of shock waves in flows over symmetrical bodies at Mach 1, *J. aero. Sci.* **20,** 7, 491–499, July 1953.

See AMR 6, Rev. 553.

853. Pai, S.-I., A note on hypersonic viscous flow over a flat plate, *J. aero. Sci.* **20,** 7, 502–504, July 1953.

Note in Readers' Forum.

854. Sedov, L. I., Integration of equations for unidimensional flow of gas (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **90,** 5, p. 735, 1953.

A particular solution is given of the full inviscid equations for unsteady radially symmetric flow (e.g., plane, cylindrical, or spherical). The solution involves four constants and a function that may be chosen arbitrarily and represents "progressing waves" similar to those discussed by Courant-Friedrichs ["Supersonic flow and shock waves," p. 419].

M. D. Van Dyke, USA

855. Mandl, P., On the transition through a weak shock front, *J. aero. Sci.* **20,** 2, 151–152, Feb. 1953.

For one-dimensional steady flow two results of analysis are stated with consequences. One of them is the factoring of the basic differential equation for the velocity for certain cases. The integral is stated for the case that one factor is set equal to zero. Whether use of the other factor gives additional solutions is not investigated. For the general case a series expansion is given, with results from calculations based on this expansion.

E. W. Beth, USA

856. Ferrari, C., On the nonpermanent flow of compressible fluids in straight ducts (French and English), *Publ. sci. tech. Min. Air. France* no. 281, 273–296, 1953.

Author discusses methods of analysis for several nonsteady one-dimensional flows. First, the characteristic lines for isentropic unsteady flow in a deformable duct with simple elasticity are found and simplified by the assumption of a linear-pressure specific-volume relation. Then the shock relations in the same deformable duct are discussed; since entropy changes are neglected, the shock and isentropic flow relations become identical. Application of the results of the above analyses to the injection of fuel in a diesel motor is outlined. Paper concludes with discussion of (a) two limiting cases of inelastic duct and slow motion and of (b) nonadiabatic flow in inelastic duct. P. A. Libby, USA

857. Cherry, T. M., A transformation of the hodograph equation and the determination of certain fluid motions, *Phil. Trans. roy. Soc. Lond.* (*A*) **245,** 904, 583–626, Apr. 1953.

A transformation is given of the hodograph equation of two-dimensional gas dynamics, from the usual variables q, θ to q and a new variable ϕ. The transformation, which suits any gas for which $p\rho^{\gamma} = \text{const}$ with $\gamma > 1$, is so chosen that certain solutions, which in terms of q, θ are multiple-valued, become single-valued functions of q, ϕ. Such a solution is represented, over the whole domain which is of interest, by a single series in q, ϕ, which is rapidly convergent; whereas in terms of q, θ, different series would be required for different branches of the function, and these would be but slowly convergent.

By this method we can construct (1) the nozzle flow for which the axial velocity is a prescribed analytic function of position, in particular transonic nozzle flows, and (2) various cases of flow past airfoil-shaped cylinders placed in a uniform stream. Taking $\gamma = 1.4$, complete numerical results are given for one case of transonic nozzle flow, and from these other such flows can be obtained by superposition, and a family of flows of type (2) is investigated, in which the trailing edge of the airfoil is cusped; the airfoil shape has been calculated for two representative values of the free-stream Mach number. A limiting flow of this family is found to consist of a set of Prandtl-Meyer flows analytically distinct but joining continuously where they abut.

These flows are related to a particular solution of the hodograph equation which is of fundamental analytic importance; it stands in the same relation to the set of Chaplígin solutions as the generating function for Legendre polynomials does to the harmonic functions $r^n P_n(\cos\theta)$.

From author's summary by C.-C. Chang, USA

858. Honda, M., Theoretical research on transonic flow (Report 1), *Rep. Inst. high Speed Mech., Tōhoku Univ.*, **3,** 51–70, Mar. 1953.

To solve problem of mixed flow past a body, author finds approximation to hodograph equation for ψ, which is valid at $M = 0$ and $M = 1$ with unknown error elsewhere. Approximate equation yields set of particular solutions behaving like $\chi^{1/2+n}$ as $M \to 0$, where $\chi = -\log(q/q_\infty) + i\theta$. For incompressible solution of form $\psi = \operatorname{Im} \sum_{n=1}^{\infty} C_{1/2+n} \chi^{1/2+n}$, he takes analogous series of particular solutions without discussion of convergence. Reviewer notes that this solution is limited to zero circulation. Numerical results at supercritical Mach numbers are given for two bodies which reduce to a circle and an ellipse, respectively, at $M = 0$. H. C. Levey, Australia

859. Dodd, K. N., A case of gaseous accretion, *Proc. Camb. phil. Soc.* **49,** part 3, 486–492, July 1953.

The author proposes to study the rate of acceleration of gas by a moving star by means of the following hydrodynamical model: A perfect gas is moving isothermally in axially symmetric supersonic flow past a gravitating point sink. The method is numerical. The results agree more or less with some guessed at by other workers. C. Truesdell, USA

Turbulence, Boundary Layer, etc.

(See also Rev. 844)

860. Liepmann, H. W., and Robinson, M. S., Counting methods and equipment for mean-value measurements in turbulence research, *NACA TN* 3037, 49 pp., Oct. 1953.

Authors consider various methods of measuring probability distributions and mean values of random functions as encountered in turbulence research. The final choice is a 10-channel statistical analyzer based on a system of pulse and amplitude modulation followed by an amplitude discriminator and a counter. Applications to the measurement of probability distributions of the axial velocity fluctuation $u(t)$ and its derivative du/dt in isotropic turbulence are shown. The assumption of independent probabilities of $u(t)$ and du/dt, which has been used as an approximation in the application of zero counts to the measurement of the microscale of turbulence λ, is investigated. The results indicate that the assumption is satisfied within a few per cent and that there is, so far, no evidence that the systematic difference between λ measured from zero counts and λ measured inde-

pendently can be traced entirely to the statistical dependence of u and du/dt.

The apparatus can be used to measure correlations of any order. It permits averaging over a long time, which should improve the accuracy of turbulence measurements.

From authors' summary by M. S. Uberoi, USA

861. Hama, F. R., The spectrum equation of two-dimensional isotropic turbulence, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 427–433, 1953.

Author derives differential equation for the energy transfer corresponding to Ogura's formula [Ogura, Y., "The structure of two-dimensionally isotropic turbulence," *J. meteor. Soc. Japan* 30, p. 59, 1952] for the energy spectrum in two-dimensional isotropic turbulence. L. M. Grossman, USA

862. Ribner, H. S., and Tucker, M., Spectrum of turbulence in a contracting stream, *NACA Rep.* 1113, 17 pp., 1953.

Supersedes article reviewed in AMR **5**, Rev. 2432.

863. Bouasse, H., Turbulent flow and loss of energy (in French), *Chaleur et Industrie* **34,** 335, 336, 337, 338; 145–156, 179–196, 217–232, 253–261, June, July, Aug., Sept. 1953.

These are unpublished memoirs of H. Bouasse and are forty years old. Various pieces of apparatus and techniques are described for producing and making visible vortexes, vortex pairs, vortex rings, and vortex trains of many descriptions. Author's criticism of theoreticians makes for amusing reading.

M. J. Goglia, USA

864. Lighthill, M. J., On the energy scattered from the interaction of turbulence with sound or shock waves, *Proc. Camb. phil. Soc.* **49,** part 3, 531–551, July 1953.

The author's general theory [AMR **6**, Rev. 654] for sound produced aerodynamically is applied to the scattering of energy when a sound wave passes through a turbulent field. The energy scattered is proportional to the sound intensity, to the square of the Mach number M of the turbulent fluctuations (ratio of the rms value of the turbulent fluctuations to the speed of sound), to the macroscale of the turbulence, and inversely as the square of the wave length of the sound. For isotropic homogeneous turbulence the directional distribution of the scattered energy is obtained as a function of the ratio of wave length to macroscale of the turbulence. If the wave length of the incident sound is less than the microscale of the turbulence, the directional distribution of energy will become quite random in a distance equal to λ/M^2, where λ is the microscale. The theory is extended to an acoustic pulse for application to the passage of a turbulent field through a shock wave. The results show, in terms of the entropy jump through the wave, the increase in the intensity of the sound field behind a shock wave. A. M. Kuethe, USA

865. Tollmien, W., Comprehensive report on progress in turbulence investigations (in German), *ZAMM* **33,** 5/6, 200–211, May/June 1953.

Paper contains a résumé on progress in turbulence up to 1951. The following items are briefly discussed: Scubauer and Skramstad's experiments and their agreement with Tollmien's theory of 1929, jointly with Dryden's progress on the subject; Lin and Foote's investigations on hydrodynamic stability; results by Ludwieg, Tillmann, Reichardt, Forstall, and Shapiro; von Kármán-Howarth's theory, spectral tensor of Kampé de Fériet and Batchelor, approach by Taylor, Darrieus, Heisenberg; energy spectrum by Dryden, Kolmogoroff, Onsager, Weizsäcker, Obukhov, Kovásznay; Loitsiankii invariant, Fourier transform, local isotropy, results of Batchelor and Townsend.

M. Z. Krzywoblocki, USA

866. Kay, J. M., Boundary-layer flow along a flat plate with uniform suction, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2628, 28 pp., May 1948, published 1953.

Experimental investigation was made in 1948 of both laminar and turbulent boundary-layer flow along a flat plate with distributed suction through a porous surface in an airstream of zero pressure gradient. Without suction early transition occurred, presumably due to roughness. With suction velocity of 0.0029 times stream velocity applied to laminar layer, the velocity distribution approaches asymptotic exponential velocity distribution and displacement thickness approaches theoretical asymptotic value. Applied to turbulent layer, distributed suction is effective in thinning the layer.

In opinion of reviewer, results with laminar layer demonstrate no stabilization but only effect of thinning layer. Laminar flow at downstream end of plate is obtained only with values of momentum thickness smaller than that for transition without suction. H. L. Dryden, USA

867. Cheng, S.-I, On the stability of laminar boundary layer flow, *Quart. appl. Math.* **11,** 3, 346–350, Oct. 1953.

Small-perturbation differential equations for stability of compressible laminar boundary-layer flows are given. These are developed in essentially the same manner as those of Lees and Lin [*NACA TN* 1115], but additional terms proportional to axial (x)-gradients and to the normal velocity component are now retained. It is shown that to a first approximation and, in fact, to the types of approximation used by previous investigators, the assumption that boundary-layer flows are parallel flows leads to consistently correct results, with the stability of the laminar boundary layer dependent only on the local mean flow properties. To obtain a second approximation, however, the effect of vertical velocity component must be taken into account. Axial gradients appear only at still the next higher approximation [of order $(\alpha R)^{2/3}$]. Author states that, at high Mach numbers, the vertical velocity component may be of importance in even the first approximation for laminar boundary-layer stability.

M. Morduchow, USA

868. Van Le, N., Transformation between compressible and incompressibile boundary-layer equations, *J. aero. Sci.* **20,** 8, 583–584, Aug. 1953.

Paper gives transformations which permit the removal of some of the restrictions under which problems of compressible boundary layers may be reduced to equivalent problems in incompressible boundary layers. Method is applicable to both laminar and turbulent conditions. D. F. Gunder, USA

869. Krzywoblocki, M. Z., On the two-dimensional laminar boundary layer equations for hypersonic flow in continuum and in rarefied gases, *J. aero. Soc. India* **5,** 1, 1–13, Feb. 1953.

The modifications in the differential equations for hypersonic boundary layers arising from higher-order terms in the stress tensor and heat flux vector are determined. The higher-order terms which are considered are those developed by Burnett [Burnett, D., *Proc. Lond. math. Soc.* **40,** p. 382, 1935] and Chapman and Cowling [Chapman, S., and Cowling, T. G., "The mathematical theory of non-uniform gases," London, Cambridge Univ. Press, 1939] from kinetic theory and are thus confined to the case of monatomic, ideal gases. An order of magnitude agreement for the boundary layer case of $Re \to \infty$ is made to determine which of the many such terms are dominant. These are given explicitly and shown to be of the order M^2/Re compared to the usual boundary-layer terms, in agreement with the general results of

Tsien [Tsien, H. S., *J. aero. Sci.* **13**, p. 653, 1946]. For the boundary-layer case they are accordingly negligible except for hypersonic flow, $M \to \infty$. For this case, the restriction to monatomic ideal gases seems, to the reviewer, a serious one. There is no discussion of the boundary conditions, which should be associated with these differential equations and which are known to differ in form by terms of order $M/Re^{1/2}$ and also possibly in number from the conventional boundary-layer case.

S. A. Schaaf, USA

870. Krzywoblocki, M. Z., On the decay of turbulence in compressible fluids in terms of vorticity, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 413–425, 1953.

Author derives formal equations describing the decay of homogeneous turbulence in a compressible fluid.

G. K. Batchelor, England

871. Blue, R. E., and Low, G. M., Factors affecting laminar boundary layer measurements in a supersonic stream, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 593–611, 1953.

See AMR **6**, Rev. 3187.

Aerodynamics of Flight; Wind Forces

(See also Revs. 769, 777, 847, 848, 909, 913)

872. Brown, W. D., Parachutes, London, Sir Isaac Pitman & Sons, Ltd., 1951, xiii + 322 pp. $8.50.

Book is believed to be the first technical treatise on research, development, and design of parachutes. In the author's words: "Its main purpose is to present, as fairly as possible, the progress which has been made in parachute design, particularly during the last eight years." Reviewer believes that this purpose has been achieved admirably and that the book will be of great value to researchers and engineers working entirely or occasionally in this field. In view of its many historical and practical comments and its pleasing literary style, it is also highly recommended for aviation historians, pilots, and other nontechnical users of parachutes.

Material of the book is based primarily on work done in Great Britain, Germany, and the United States from 1942 to 1949. In addition to personnel parachutes, special parachutes are discussed for dropping of equipment and armament, braking of aircraft, and stabilizing of towed or ejected bodies. Besides a mere description of the various designs and their uses, the principal aerodynamic, dynamic, and strength characteristics are derived and discussed. This includes topics such as critical opening and closing speeds, landing velocities, squidding, fabric porosity, snatch loads, stability, general performance; strength of materials; design procedure, and problems of deployment, attaching and packing parachutes.

To do justice to the scope of the book, the chapter headings are listed herewith: Introduction; Motion of a falling body; The purpose of parachutes and their uses; Parachute materials and their physical characteristics; Porosity and its measurement; The aerodynamics of a parachute—opening characteristics; The aerodynamics of a parachute—drag; The aerodynamics of a parachute—stability; Strength of parachutes; Paper parachutes; Drogues; Design procedural deployment; Parachute packs and containers; The emergency or life-saving parachute; The military parachute; Dropping of explosive and incendiary stores; Dropping of supplies and heavy equipment; Antispin and aircraft brake parachutes; Rot and mildewproofing; Repairs and the useful life of parachute assemblies; Testing of parachutes; List of symbols; Glossary of parachute terms.

Author is quite frank about parachute problems which cannot be solved at this time due to lack of analytical treatment or basic experimental data. For instance, no aerodynamic coefficients, stability derivatives, or apparent mass parameters are available for stability calculations; the validity of scale-model testing must also remain in doubt until the important similarity parameters for parachute systems have been determined. The book, therefore, points out the areas where scientific work should be done to advance the state of the art.

The research-minded reader will be puzzled by the lack of a bibliography in view of the many individuals mentioned by name in the text. It can only be conjectured that the author was not at liberty to publish specific references at this time. It is hoped, however, that he may be able to do so in future editions of his book.

H. P. Liepman, USA

873. Goodson, K. W., and Draper, J. W., Effects of symmetric and asymmetric thrust reversal on the aerodynamic characteristics of a model of a twin-engine airplane, *NACA TN* 2979, 67 pp., Sept. 1953.

Paper presents results of an experimental investigation at low speeds of effects of thrust reversal for twin-engine propeller-driven airplane. It was found that the variation of lift with total thrust coefficient was approximately linear throughout the complete range of positive and negative thrusts. With this established, it was shown that the rolling moment due to asymmetric thrust was approximately equal to the product of the differential lift between the right and left wing (established from the experimental variation of total lift with thrust coefficient) and the lateral distance to the propeller thrust axis. The yawing moment due to propeller thrust reversal was approximately equal to the product of asymmetric thrust and the lateral distance to the thrust axis. It is somewhat surprising but extremely gratifying that such a simplified analysis yields such good agreement with experiment. The investigation showed that for extreme asymmetric-thrust conditions, the rolling and yawing moments are of such magnitude that lateral and directional control may be inadequate for twin-engine airplanes.

R. M. Crane, USA

874. Rutowski, E. S., Energy approach to the general aircraft performance problem, *Douglas Aircr. Co. Rep.* no. SM-14875, 28 pp., 6 figs., July 1953.

A unified discussion of all of the principal problems in airplane performance analysis beginning with the power or "energy balance" equation. Author claims to have disposed of the difficult problem of determining the paths for minimum-time-to-climb and minimum-fuel-to-climb by considering only the terminal specific energies (kinetic plus gravitational potential) rather than the particular terminal altitudes and speeds required. However, author's conclusions relative to transitions between the optimum paths derived and arbitrary specified terminal conditions "by means of a dive or a zoom" do not appear to have been thoroughly investigated or substantiated and seem somewhat doubtful, especially in the case of the minimum-time problem.

R. M. Stewart, USA

875. Lush, K. J., The effect of compressibility on the attitude of aircraft in rectilinear flight, *Aero. Res. Counc. Lond. Rep. Mem.* 2776, 7 pp., Mar. 1948, published 1953.

The attitude of aircraft (i.e., the angle between the aircraft datum and the flight path) is of considerable importance in the aiming of certain airborne armament. An investigation was therefore made of the effect of compressibility on the attitude of aircraft in flight in a straight path.

From author's summary

876. **Warren, C. H. E., The definitions of the angles of incidence and of sideslip,** *Aero. Res. Counc. Lond. curr. Pap.* 124, 11 pp., Aug. 1952, published 1953.

The use of large angles of incidence and of sideslip in missile work and recent changes in wind-tunnel testing techniques have shown the need for clear and precise definitions of the angles of incidence and of sideslip. The suitability of different definitions for both experimental and theoretical work in both the aircraft and missile field is considered, and it is concluded that, as no single definition is universally acceptable, care should be taken in theoretical and experimental reports to define precisely the angles used. From author's summary

877. **Miele, A., General solutions of optimum problems in nonstationary flight** (in Italian), *Aerotecnica* **32,** 3, 135–142, June 1952.

This communication is a generalization of author's previous solution [AMR **4,** Rev. 3954] of the minimum-time climb problem to the following external flight problems: (a) climbing flight of minimum fuel consumption; (b) steepest climbing flight; (c) maximum time descending flight; (d) maximum horizontal distance descending flight.

Determination of velocity distribution $V(Z)$ for conditional extremals corresponding to flight from given initial condition (V_1, Z_1) to final condition (V_2, Z_2) gives a method for selecting optimum flight techniques.

Admitting that airplane weight Q is constant, thrust $T = T(V, Z)$, fuel consumption is $q = q(V, Z)$, and neglecting squares of path inclination, centrifugal forces, and the angle defined by the velocity and thrust vectors, the dynamical equation leads to a variational fixed end-points problem. The integrand being linear in $V'(Z)$, the necessary Euler condition in this singular case is a finite terms equation: $\omega(V, Z) = (\partial x/\partial V) - (V/G\partial x/\partial Z) = 0$ which defines implicitly the extremals if end points satisfy the conditions $\omega(V_1, Z_1) = 0$, $\omega(V_2, Z_2) = 0$.

In general, these conditions are not satisfied and this problem, which author calls minimum absolute problem, has no indirect solution, even if he mentions it without giving the effective construction of the $V(Z)$ optimal end arcs through (V_1Z_1), (V_2Z_2) intersecting $(V, Z) = 0$.

A conditional solution of flight technical interest is, however, given with extremals of $(V, Z) = 0$ central part and two $z =$ const end arcs. The minimal or maximal character of these extremals relative to the class of all possible arcs $V(Z)$ ending in $z =$ const pieces through (V_1, Z_1), (V_2, Z_2) can be proved by Riemann's formula.

The functions $x = x(V, Z)$, satisfying the extremal conditions for steady flight, also satisfy $\omega(V, Z) = 0$ and are $(T - R)V$, $(T - R)V/q$, $T - R$, and RV for cases (a), (b), (c), (d), respectively, $R = R(V, Z)$ being the drag. Limit for $T \to 0$ of case (b) solution is coincident with that corresponding to gliding flight for maximum distance in a steady analysis. The paper concludes with critical notes about the physical nature of the results obtained, stating that the two corners of $V(Z)$ for $Z_1 < Z < Z_2$ possibly do not appear in an exact dynamical formulation of the problem.

In these circumstances, the integrand would not be linear in $V'(Z)$ and the Euler equation would be regular, i.e., differential of the second order, with a particular solution which joins (V_1, Z_1) with (V_2, Z_2) being the desired extremal. This does not happen in the degenerate case analyzed by the author. If, in practice, end arcs with $z =$ const do not correspond to an important part of the trajectory, this approximate solution may be very useful, since it avoids the use of direct or indirect variational methods. R. R. Hunziker, Argentina

878. **Beavan, J. A., Sargent, R., North, R. J., and Burrows, Miss P. M., Part I; North, R. J. and Burrows, Miss P. M., Part II, Measurements of maximum lift on 26 aerofoil sections at high Mach number,** *Aero. Res. Counc. Lond. Rep. Mem.* 2678, 31 pp., Jan. 1948, published 1953.

Curves of C_L vs. α for various M, and $C_{L\max}$ vs. M are given for each airfoil tested. Latter included conventional as well as NACA and other low-drag sections. Most tests were made on 2-in. chord sections at Reynolds number up to 0.75 million, Mach number M up to 0.85, and incidence α up to 15°. Lift was determined by pressure measurement on tunnel walls.

In general, the C_L peak characteristic of low M changed at an M within range of observation to a continuous rise of C_L with α. Below this critical M, the known falling off of $C_{L\max}$ with increasing M is evidenced. At Mach numbers greater than 0.6, section characteristics conducive to increasing maximum lift are thinness, camber, and rearward location of maximum camber position.
J. S. Isenberg, USA

879. **Schultze, E., On the calculation of the spanwise center of pressure on a wing of small aspect ratio** (in German), *ZAMP* **4,** 3, 207–214, 1953.

Author first points out that the Prandtl and Weissinger wing theories fail to give the spanwise distribution of the center of pressure. He then proposes a model replacing the wing, consisting of two bound vortexes, for the calculation of the lift and moment distribution. The positions of the two bound vortexes and the two lines for satisfying the downwash conditions are determined so that the lift and moment with this model are correct if applied to two-dimensional airfoils, and the first three terms of the Fourier development of the chordwise vorticity distribution are retained.

Apparently the author is not aware of the work of Holme [*KTH Aero TN* 6, 1949], who has proposed the same model of vortexes. Reviewer questions if the position of the vortexes, which is determined for two-dimensional airfoils, has any special advantages also for wings of small aspect ratio. T. R. Gullstrand, Sweden

880. **Watkins, C. E., and Berman, J. H., Velocity potential and air forces associated with a triangular wing in supersonic flow, with subsonic leading edges, and deforming harmonically according to a general quadratic equation,** *NACA TN* 3009, 61 pp., Sept. 1953.

An extension of the work given in *NACA Rep.* 1099, taking the elastic deformation of the wing into account. The wing is undergoing a general second-degree form of harmonic distortion in both spanwise and chordwise directions. The velocity potential is expanded in terms of the frequency of oscillation and the first few terms of the expansions are presented. Flutter coefficients and stability derivatives may be obtained from such a velocity potential.

This method is also applicable to cases of supersonic leading edges. S. I. Pai, USA

881. **Kainer, J. H., Equations for the loading on triangular wings having supersonic leading and trailing edges due to various basic twist distributions,** *J. aero. Sci.* **20,** 7, 469–476, July 1953.

Applying linearized supersonic-flow theory, detailed results are obtained for potential pressure and span-load distributions due to constant, linear, parabolic, and cubic twist distributions for rigid wings. Secondly, the basic span-load distributions are presented from which the aeroelastic problem described elsewhere [AMR **5,** Rev. 846] may be solved. Span loading is presented in a concise form independent of trailing-edge sweep. Design charts for the rapid evaluation of the pressure and span-load distribu-

tions are presented. A suggestion for treatment of wing-body interference is also given. A. van Heemert, Holland

882. Behrbohm, H., The flat triangular wing with subsonic leading edges in sideslip at supersonic speeds, *SAAB Aircr. Co. TN* 14, 23 pp., 1953.

The perturbation velocity potential of a yawed triangular wing is derived in an elementary way from that for an unyawed wing. In body axes the potential of the yawed and unyawed triangular wing are the same except for a simple factor dependent on Mach number, sideslip angle, and the apex angles of the original and the transformed wing. Thus it is possible to give the spanwise load distribution of the triangular wing in sideslip in a simple closed form. The upwash in front of the yawed wing is also obtained. G. E. Nitzberg, USA

883. Kelly, J. A., and Hayter, Nora-Lee F., Lifting and pitching moment at low speeds of the NACA 64A010 airfoil section equipped with various combinations of a leading-edge slat, leading-edge flap, split flap, and double-slotted flap, *NACA TN* 3007, 45 pp., Sept. 1953.

A two-dimensional low-speed tunnel investigation at Reynolds numbers 2 to 7 million. Results indicate combined effect of leading- and trailing-edge devices in increasing maximum section lift coefficient approximately equal to sum of individual increments. Extension of leading-edge slat and deflection of leading-edge flap increased maximum lift coefficient by 0.83 and 0.66, respectively. J. S. Isenberg, USA

884. Houbolt, J. C., Correlation of calculation and flight studies of the effect of wing flexibility on structural response due to gusts, *NACA TN* 3006, 14 pp., Aug. 1953.

Studies made to evaluate the influence of wing-bending flexibility on the structural response to gusts of two twin-engine transports and one four-engine bomber are summarized. The studies encompass some previously reported and some new flight studies, some calculation studies based on discrete- or single-gust encounter, and some new calculation studies for continuous-turbulence encounter, based on the methods of generalized harmonic analysis. It is shown that the discrete-gust approach reveals the general nature of the flexibility effects and leads to qualitative correlation with flight results. The studies based on the harmonic-analysis approach show good quantitative correlation with flight results and allow for a much greater degree of resolution of the flexibility effects. The good agreement shown suggests that a suitable approach for calculating the flexibility effects is now available. From author's summary

885. Byrd, P. F., and Huggins, Mary T., Calculation of vortex distribution and lift of a thin airfoil in a tandem cascade in compressible flow (in German), *Ing.-Arch.* **21,** 3, 191–193, 1953.

Using the method of singularities, the integral equation for the chordwise lift distribution of infinitely thin airfoils in two unstaggered tandem cascades is given for subsonic flow. The integral equation can be solved analytically on the same lines as given by J. Dörr [title source, **19,** p. 66, 1951] for a single cascade, and by K. Nickel [ibid., **20,** p. 6, 1952] for multiplane wing arrangements. The solution is specialized for flat-plate tandem cascades and is also extended to the case of a symmetrical profile cascade at zero lift. H. Schlichting, Germany

886. Williams, J., and Love, E. M., Surface slopes and curvatures of the RAE 100-104 and other rooftop-type aerofoil sections, *Aero. Res. Counc. Lond. curr. Pap.* 129, 11 pp., Oct. 1952, published 1953.

887. Mirels, H., Lift effectiveness of slender wings on cylindrical bodies, *J. aero. Sci,* **20,** 7, 504–505, July 1953.

Note in Readers' Forum.

888. Weinstein, I., and Kapryan, W. J., The high-speed planing characteristics of a rectangular flat plate over a wide range of trim and wetted length, *NACA TN* 2981, 29 pp., July 1953.

In order to extend the range of available planing data, the principal high-speed planing characteristics for a prismatic surface having an angle of dead rise of 0° (flat bottom) have been determined over a wide range of planing variables. Wetted length, resistance, center-of-pressure location, and draft were determined at speed coefficients ranging up to 25.0, beam loadings up to 87.3, and trims up to 30°. Mean wetted lengths up to 7.0 beams were obtained wherever possible. The data indicate that the important planing characteristics are independent of speed and load for a given trim and are dependent primarily upon lift coefficient. The ratio of center-of-pressure location forward of the trailing edge to the wetted length is a constant equal to 0.71 up to 9° of trim. This ratio decreases with a further increase in trim angle.

From authors' summary

889. Adams, M. C., Some extensions of slender-wing theory, Cornell Univ., Grad. School of Aero. Engng., Ithaca, N. Y., 60 pp., June 1953.

Paper is a somewhat more detailed version of two previous publications. See AMR **6,** Revs. 1329, 3136.

H. N. Abramson, USA

890. de Haller, P., Influence of profile camber on the characteristics of airfoil cascades (in French), *Bull. tech. Suisse Rom.* **79,** 9–10, 133–135, May 1953.

Author states that discrepancy in results of experiments and theories [Legendre, AMR **3,** Rev. 1536; Garrick, AMR **1,** Rev. 860; Scholz, AMR **4,** Rev. 2095; Lighthill, AMR **2,** Rev. 376] for flow through staggered cascades of airfoils is due not to friction nor boundary layer but to effects of profile thickness.

After mapping conformally two circular arcs which intersect in diameter end-points of unit circle in ζ-plane, onto unit circle of ζ'-plane which represents cascade of airfoils with thickness, potential flow and circulation are calculated. This calculation is compared to circulation around single airfoil of same thickness; this ratio is called the effect of the cascade.

Curves are presented of α vs. chord-gap ratio for 0 and 70° of stagger, and for airfoils of 0 and 10% thickness for several values of C_a. Although curves take same shape as experimental, author feels that remaining inaccuracy is probably due to neglecting effect of twist. M. D. Friedman, USA

891. Bryson, A. E., Jr., Stability derivatives for a slender missile with application to a wing-body-vertical-tail configuration, *J. aero. Sci.* **20,** 5, 297–308, May 1953.

Under the usual assumption that in the vicinity of the body the flow pattern in any transverse plane is the same as in two-dimensional incompressible flow, the slender-body theory of Munk and Jones, employing the concept of inertia coefficients, is extended to the computation of all the nonaxial stability derivatives of a three-dimensional missile configuration. The inertia coefficients of the cross section are determined from the two-dimensional velocity potential by a method employing matrix expressions and the total forces and moments on the body derived by integration over the body length. The force and moment coefficients are derived for a flat delta wing, it being noted that the resultant expressions contain additional terms to the expressions deduced by

Ribner [AMR 1, Rev. 695]. By using a conformal mapping method, the theory is applied to compute the theoretical stability derivatives of a slender wing-body-vertical tail configuration.

G. V. Bull, Canada

892. **Bleviss, Z. O., and Struble, R. A., Some effects of streamwise gaps on the aerodynamic characteristics of low-aspect-ratio lifting surfaces at supersonic speeds,** *Douglas Aircr. Co. Rep.* SM-14627, 89 pp., Apr. 1953.

An engineering attack on an important practical problem of wing theory, viz., the effect of a gap between the fixed and movable portions of a wing or between a wing and body. The idealized case treated here is that of a parallel, central, streamwise gap in a plane delta wing, which also represents a half-delta wing near a wall. The approximations of linearized supersonic-flow theory are made. For both subsonic and supersonic leading edges, the cases of zero and infinite gap width are first treated. For each value of the leading-edge-sweep parameter d (ratio of tan (*wing apex angle*) to tan (*Mach angle*)) there is a minimum value of the gap-span ratio k for which interference across the gap occurs; this is the "effectively-infinite" gap ratio k_e, and the infinite-gap results apply to all $k > k_e$. To fill in the important interval $0 < k < k_e$, the authors first carry out the slender-body (Jones) case, $d \to 0$, for the whole range of k. For other values of d, part of the interval is filled in by calculating in detail the cases of single interaction. The rest of the interval, nearer to $k = 0$, is filled in by interpolation.

On this approximate basis, a number of useful engineering data are computed, such as the center-of-pressure location, drag due to lift, and wake data for wing-tail interference. The report concludes with a qualitative discussion of the viscous effects, which are probably large for small gaps. The study should be of considerable practical value, in spite of its rather rough nature.

W. R. Sears, USA

893. **Fradenburgh, E. A., and Wyatt, DeM. D., Theoretical performance characteristics of sharp-lip inlets at subsonic speeds,** *NACA TN* 3004, 21 pp., Sept. 1953.

Paper describes a one-dimensional momentum method.

M. V. Morkovin, USA

894. **Gilman, J., Jr., Propeller-performance charts for transport airplanes,** *NACA TN* 2966, 70 pp., July 1953.

The preliminary selection of a propeller on the basis of cruising and take-off performance for application to transport airplanes at flight Mach numbers up to 0.8 can be accomplished by the use of the charts and methods presented. The charts are of sufficient scope to permit a fairly rapid evaluation of the propeller performance for engine power ratings of 1000 to 10,000 hp. The method is presented primarily in the interest of propeller-noise abatement. From author's summary

895. **Serafini, J. S., Impingement of water droplets on wedges and diamond airfoils at supersonic speeds,** *NACA TN* 2971, 62 pp., July 1953.

Curves of coefficients of capture for these supersonic airfoils are presented. M. Tribus, USA

896. **Young, A. D., The aerodynamic characteristics of flaps,** *Aero. Res. Counc. Lond. Rep. Mem.* 2622, 55 pp., Feb. 1947, published 1953.

This report summarizes the important aerodynamic characteristics of all types of aerodynamic flaps including split, slotted, multiple, Fowler, Blackburn slotted, venetian blind, and drag flaps, as well as slots in conjunction with these flaps. Lift, profile drag, and pitching-moment coefficient increments are discussed from a theoretical standpoint and the results of extensive experimental studies are also shown. The work includes that of many countries and is an excellent summary of the entire field. In particular, an attempt is made to correlate the basic characteristics of various types of flaps with each other, which correlation is then used in charts and tabulations to enable designers to predict results for the use of any particular kind of flap arrangement.

In addition to the above theoretical and experimental information, the report includes an extensive bibliography of the most important reports and papers which a reader might wish to use for more detailed information in this field.

E. A. Bonney, USA

897. **Iserland, K., Braking the landing run of jet aircraft by thrust deviation,** *Interavia* no. 3, 4 pp., 1953.

Comprehensive study of braking thrust obtained from jet deviation. Aircraft braking requirements are analyzed, experimental equipment described, data discussed. Negative thrust of 60% of static thrust obtained. H. R. Ivey, USA

898. **Rosser, J. B., Newton, R. R., and Gross, G. L., Mathematical theory of rocket flight,** New York, McGraw-Hill Book Co., Inc., 1947, viii + 276 pp. (2nd impression, 1953.)

See AMR 1, Rev. 912.

Aeroelasticity (Flutter, Divergence, etc.)

(See Revs. 684, 776, 880)

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 694, 841, 843, 910, 913, 945)

899. **Davidson, R. E., Linearized potential theory of propeller induction in a compressible flow,** *NACA TN* 2983, 47 pp., Sept. 1953.

The potential of the linearized flow for a lifting-line propeller of arbitrary circulation distribution at subsonic advance is derived in cylindrical harmonics. From the potential the induced angle at the lifting line is obtained. A phenomenon resembling resonance in vibrating systems introduces itself in that one term in the series becomes very large compared to the others. The main consequence of this phenomenon is that the lift distribution cannot be arbitrarily prescribed; on the other hand, the inverse problem, in which the propeller geometry is given, is acceptable.

R. C. Binder, USA

900. **Stanitz, J. D., Effect of blade-thickness taper on axial-velocity distribution at the leading edge of an entrance rotor-blade row with axial inlet, and the influence of this distribution on alinement of the rotor blade for zero angle of attack,** *NACA TN* 2986, 33 pp., Aug. 1953.

A method is developed for estimating the effect of blade-thickness taper on the inlet axial-velocity distribution of an entrance rotor-blade row with axial inlet, and the influence of this velocity distribution on the alignment of the rotor blade for zero effective angle of attack (that is, zero blade loading at the nose). This alignment of the blade requires a deviation between the angle of the blade camber line direction at the inlet and the upstream relative flow direction. The method is developed for compressible and incompressible nonviscous fluids, and results are presented for incompressible flow into a plane two-dimensional cascade and for compressible flow into an entrance rotor-blade row with tapered blades. It is concluded that, for the entrance rotor-blade row in-

vestigated, blade taper has a large effect on the inlet deviation angle; whereas compressibility has a small effect, except perhaps at the hub, and the upstream relative flow direction also has a small effect. From author's summary

901. Wyatt, DeM. D., An analysis of turbojet-engine-inlet matching, *NACA TN* 3012, 19 pp., Sept. 1953.

For optimum performance of turbojets over the whole required flight range, the flow requirements of the engine and the inlet system must be matched. Such matching procedure is developed by the author. The engine air-flow requirements as well as the inlet air flow are presented in dimensionless parameters. For a particular engine, the air requirements and the flow through a fixed-geometry inlet are drawn with the Mach number as abscissa. It is shown that matching can be achieved at one operating point only. For matching over the whole operating range, the lip area, the critical mass-flow ratio, or the critical pressure ratio of the inlet have to be varied. These methods of matching are discussed in detail and are illustrated graphically. T. P. Torda, USA

902. Swanson, W. M., Complete characteristic circle diagrams for turbomachinery, *Trans. ASME* **75,** 5, 819–826, July 1953.

The experimental test results for operating a hydraulic turbomachine in every possible manner (noncavitating) are presented for a representative single-stage axial-flow and mixed-flow pump. A comparison is made among the three basic types of machine—axial, radial, and mixed flow. A new method of representing, on a single diagram, the efficiencies in all types of operation is proposed and demonstrated for the case of these three pumps. A method for predicting the complete characteristics from ideal flow considerations is given. Author's summary

Reviewer believes this paper will be of value in showing general trends of complete characteristics. The numerical values must, however, be used with caution since they are based on the academic Euler infinite-vane theory.

H. H. Anderson, Scotland

903. Hargest, T. J., The theoretical pressure distribution around some conventional turbine blades in cascade, *Aero. Res. Counc. Lond. Rep. Mem.* 2765, 10 pp., Mar. 1950, published 1953.

This report presents comparative results between theoretical pressure distributions around a specific series of turbine blades in cascade arrangement and the observed aerodynamic performance of blades of the same shape as tested in the No. 3 high-speed cascade tunnel of the National Gas Turbine Establishment.

The theoretical pressure distributions around the blades were determined over the range of incidence covered in the aerodynamic tests by means of Relf's analogy between aerodynamic streamline flow and electric potential flow. It is shown that these theoretical pressure distributions and their variation with incidence can explain the corresponding cascade test results and can form a basis of general comparison of the turbine cascades.

F. L. Wattendorf, USA

904. Parmakian, J., Pressure surges at large pump installations, *Trans. ASME* **75,** 6, 995–1004, Aug. 1953.

See AMR **6,** Rev. 1944.

905. Carter, A. D. S., Some tests on compressor cascades of related aerofoils having different positions of maximum camber, *Aero. Res. Counc. Lond. Rep. Mem.* 2694, 17 pp., Dec. 1948, published 1953.

The influence of the position of maximum camber on the aerodynamic performance of five related airfoil cascades has been determined experimentally in a high-speed cascade tunnel. The results show that, with the maximum camber well forward, the blades have a wide operating range and a low critical Mach number (drag rise). Moving the maximum camber position back narrows the working range but increases the critical Mach number, giving an increased work output for an equivalent compressor stage. From this work and a previous theoretical study [AMR 4, Rev. 755], author concludes that the maximum camber at 50% chord gives a fair compromise.

Author warns that results may not apply to actual compressor stages where secondary flow effects may be large.

F. G. Blight, Australia

Flow and Flight Test Techniques

(See also Rev. 883)

906. Phillips, D. S. M., A robust air-flow meter for field use, *J. sci. Instrum.* **30,** 10, 382–383, Oct. 1953.

An air-flow meter is described which employs a series of small metering orifices as flow controls at a fixed pressure. The meter was designed for use in milking-machine tests where air-flow levels in the range 0 to 50 cu ft per min are encountered at a negative pressure of 15 in. of mercury. This instrument may have application in similar fields where a portable instrument is required.

R. C. Binder, USA

907. Farbar, L., The venturi as a meter for gas-solids mixtures, *Trans. ASME* **75,** 5, 943–950, July 1953.

See AMR **6,** Rev. 2336.

908. Stoll, H. W., The pitot-venturi flow element water service report, *Trans. ASME* **75,** 5, 969–974, July 1953.

Paper is an extension of previous work by the author [title source, **73,** 7, 963–969, 1951] on design characteristics of a double-venturi meter for measuring air speeds, factors influencing its coefficient, flow equations, and installation considerations. The present work deals with such an instrument for measuring liquid flow in closed channels and reports performance information and assembly requirements when water is used. Also included is a further analysis on the velocity/pressure equations involved.

Experiments performed with this flow element of $1^5/_8$-in. outer diameter in pipes of 4 in. and 6 in., respectively, show that the calibration factor of the instrument is a function of the diameter ratio, flow rate, and design features. Each instrument must be calibrated individually to ascertain the correct value of that factor.

Author recommends the use of a multiple-orifice damping unit between flow element and pressure recorder in the case where the flow is unsteady. Such damping units smooth out the operation of the recorder but, on the other hand, cause erroneous pressure recording because the pressure drop across an orifice-damping unit does not vary linearly with the velocity through it. In reviewer's opinion, only units with a linear characteristic should be used. The possibility of breaking of the liquid column during rapidly decreasing pressure remains, however. This independent source of errors is inherent in all damping units and yields too high a recorded mean pressure.

B. G. van der Hegge Zijnen, Holland

909. Holder, D. W., North, R. J., and Chinneck, A., Experiments with static tubes in a supersonic airstream. Parts I and II, *Aero. Res. Counc. Lond. Rep. Mem.* 2782, 14 pp., 1953.

Systematic tests at $M = 1.6$ of a family of static tubes are described. Results show the effects of nose shape, distance of holes from nose, angle of yaw, proximity to a wall, and interference with a dummy support.

A flat-nosed pitot tube was also investigated at $M = 1.6$ and 1.8. No change in reading could be detected when the bore was changed from $^1/_2$ to $^1/_{16}$ of the external diameter.

J. V. Becker, USA

910. **Squire, H. B., Experiments on conical diffusers,** *Aero. Res. Counc. Lond. Rep. Mem.* 2751, 18 pp., Nov. 1950, published 1953.

Paper reports subsonic tests made on circular diffusing sections of area ratio 4 and total cone angles from 4 to 10° in order to determine the effect of Reynolds number on efficiency. Uniform entry conditions were maintained and the range of Reynolds numbers covered was between 5×10^4 and 10^6.

No significant variation in efficiency with cone angle was found, but a gradual improvement in efficiency with increasing Reynolds number was indicated. Check measurements on pressure distributions along the wall and velocity distributions at the end of the conical sections were made, but no boundary-layer separation for any of the cones was found. These latter tests were also extended to area ratios of 16 and again no boundary-layer separation for cone angles up to 10° was indicated.

Author concludes that unsatisfactory flow efficiencies in conical diffusers for cone angles up to 10° must, therefore, be due to poor entry flow conditions. G. C. Quigg, Australia

911. **Higton, D. J., Plascott, R. H., and Clarke, D. A., The measurement of the overall drag of an aircraft at high Mach numbers,** *Aero. Res. Counc. Lond. Rep. Mem.* 2748, 22 pp., Jan. 1949, published 1953.

Paper presents British method of determining high Mach number jet-aircraft drag from level flight and dive tests. Wing-tunnel and flight drags of the Meteor IV airplane are shown to be in good agreement. H. Luskin, USA

912. **Bryson, A. E., Jr., An experimental investigation of transonic flow past two-dimensional wedge and circular-arc sections using a Mach-Zehnder interferometer,** *NACA Rep.* 1094, 33 pp., 1952.

Supersedes article reviewed in AMR **5**, Rev. 2425.

913. **Gustafson, F. B., and Crim, A. D., Flight measurements and analysis of helicopter normal load factors in maneuvers,** *NACA TN* 2990, 29 pp., Aug. 1953.

Flight tests have been conducted in two single-rotor helicopters to determine the load factors due to various maneuvers. A simple theoretical method of estimating for new designs the maximum load factor that can be attained for any given flight condition is also presented and the results are compared with those obtained from the flight tests. From authors' summary

914. **Taneda, S., Studies on wake vortices I,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **1**, 4, 131–144, Dec. 1952.

An interesting photographic study of the vortex street at low Reynolds numbers behind a finite cylinder has been made. The technique followed employs an alumina flake suspension in water, illuminated in different planes so that the structure of the vortex tubes can be progressively studied. The photographs show the usual von Kármán structure as well as an effect of the end of the cylinder on the vortex street. The discrete two-dimensional vortex filaments appear to be connected to each other by an orthogonal linkage of vortex tubes lying approximately at the level of the cylinder end. While it is known that the vortex street spreads laterally, it appears to contract relative to the longitudinal axis of the cylinder. H. M. Spivack, USA

915. **Braun, W., Strength tests by towing in water,** *Aircr. Engng.* **25**, 287, 22–25, Jan. 1953.

Paper reports on strength tests to deformation and failure of airplane structures towed under water at a towing tank at Hamburg, Germany. The tests were conducted before and during the war and were devised as a rational test method for designing cockpit hoods. They were later extended to tests of the Me 210 and the He 162 wings, and reproduced the premature failure load of these wings as well as the modes of failure. The method is rational and may certainly be more accurate than conventional static loads by weights or hydraulic actuators; it deserves further study.

The test velocity used was $^1/_{28}$ of the indicated flight speed. Disadvantages of the method are the possibility of cavitation and the incompressibility of water.

Reviewer performed similar tests in a towing tank in Guidonia, Italy, obtaining failure on wing models at zero lift and combined torsional and bending divergence. [See Riparbelli, C., "Proposta di un metodo per il collaudo di strutture aeronautische," VI Convegno di Aerotecnica, Maggio 1940.] Reviewer believes method is very interesting and suggests that compressibility might be introduced by using a mixture of air and water.

For complete similitude, acceleration should be scale velocity. Setup might be used to emphasize and study effects of acceleration in nonsteady motion. C. Riparbelli, USA

Thermodynamics

(See also Revs. 800, 801, 932, 939, 941, 942, 947, 978)

916. **Thomsen, J. S., Logical relations among the principles of statistical mechanics and thermodynamics,** *Phys. Rev.* **91**, 5, second series, 1263–1266, Sept. 1953.

Five propositions used in thermodynamics and statistical mechanics are formulated: Detailed balance, microscopic reversibility, the ergodic hypothesis, the second law, and a restriction on the transition probabilities which will be termed the "λ hypothesis." It is shown that the last three propositions are equivalent. The ergodic hypothesis and detailed balance together are proved to be equivalent to microscopic reversibility. This shows that microscopic reversibility is a stronger condition than the second law. The results are discussed in connection with Onsager's principle.

From author's summary by R. E. Street, USA

917. **Ishkin, I. P., and Brodyanskiĭ, V. M., Thermodynamic analysis of irreversible low-temperature processes. I, II** (in Russian), *Zh. tekh. Fiz.* **22**, 11, 1773–1793, Nov. 1952.

918. **Onsager, L., and Machlup, S., Fluctuations and irreversible processes,** *Phys. Rev.* (2) **91**, 6, 1505–1512, Sept. 1953.

The probability of a given succession of (nonequilibrium) states of a spontaneously fluctuating thermodynamic system is calculated on the assumption that the macroscopic variables defining a state are Gaussian random variables whose average behavior is given by the laws governing irreversible processes.

This probability can be expressed in terms of the dissipation function; the resulting relation, which is an extension of Boltzmann's principle, shows the statistical significance of the dissipation function. From the form of the relation, the principle of least dissipation of energy becomes evident by inspection.

From authors' summary

919. **Machlup, S., and Onsager, L., Fluctuations and irreversible process. II. Systems with kinetic energy,** *Phys. Rev.* (2) **91,** 6, 1512–1515, Sept. 1953.

Authors' results (see preceding review) are extended to second-order systems, i.e., systems with inertia. Using a generalized definition of the thermodynamic forces, reciprocal relations for the dissipative coefficients in the equations describing irreversible processes are derived. A dissipation function can again be defined and it can be used to express the probability functional for fluctuations. From authors' summary

920. **Hall, N. A., Nonequilibrium thermodynamics,** *J. appl. Phys.* **24,** 7, 819–825, July 1953.

Following a review of various concepts in irreversible thermodynamics, the author presents a discussion of thermostatic isolation. This important subject provides a means whereby the engineer may establish a thermostatic state for a nonequilibrium system. The nonequilibrium systems are differentiated from the corresponding equilibrium systems by the occurrence of entropy production. The author discusses the relation of the ultimate limits of applicability of thermodynamics to the uncertainty in establishing a thermostatic state under conditions of microscopic fluctuations. Time spent in the study of the concepts and ideas presented in this paper are justified for those engineers interested in the analysis of nonequilibrium engineering systems.

G. A. Hawkins, USA

921. **Bird, R. B., Hirschfelder, J. O., and Curtiss, C. F., Survey of the equation of state and transport properties of gases and liquids,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 3–84, 1953.

Application of statistical mechanics to the prediction of equation of state and of transport properties of gases is reviewed. Extensive tables of parameters in the Lennard-Jones potential (for nonpolar molecules) and in the Stockmayer potential (for polar molecules) are given for substantially all substances for which reliable experimental data are available. Empirical relationships are listed for estimating these parameters from values of properties at the critical point, at the melting point, etc. Calculations of virial coefficients, viscosity, thermal conductivity, diffusion coefficient are facilitated by extensive tables of pertinent functions.

This excellent survey should be very useful either for rational formulation of experimental data or for prediction of approximate values of properties when only incomplete experimental data are available. S. Gratch, USA

922. **London, J. C., Improvements in thermal efficiencies with single-stage reheating at high steam pressures and temperatures,** *Instn. mech. Engrs. Proc.* (*B*) **1B,** 7, 259–269, 1952.

Author presents results of calculations on thermal efficiencies of large steam turbine plants. Attention is directed chiefly to improvement of thermal efficiency by addition of single-stage reheating to a turbine plant already possessing regenerative feedheating. Results are presented graphically for steam pressures of 900, 1200, 1500, and 2000 psig.

Author's calculations indicate that improved heat consumption is obtained by extracting feed-heating steam before reheater. Improvements of thermal efficiencies by 10% are suggested by the paper for plants with single-stage reheating as compared with plants without reheating. W. A. Wolfe, Canada

923. **Millar, G. H., Winans, J. G., Uyehara, O. A., and Myers, P. S., A fast, electro-optical, hot-gas pyrometer,** *J. opt. Soc. Amer.* **43,** 7, 609–617, July 1953.

The theory, development, and design features of a fast, electro-optical pyrometer are given. This pyrometer, whose response can be made very rapid, will continuously indicate the temperature of hot gases that are either naturally luminous or are made luminous at particular wave lengths. A discussion is given of the defined terms, emissivity, and absorptivity.

From authors' summary

924. **Hunsinger, W., Instrumentation for thermoelectric measurement of temperature for high degree of accuracy, especially for thermal analysis** (in German), *Z. Metallk.* **44,** 6, 261–264, June 1953.

Description of conventional and improved methods of recording with accuracy a thermocouple signal. Feedback is used over a galvanometer and photocell arrangement. With proper bias, the system can record with great accuracy a temperature varying between two very narrow limits. This permits observation of any sharp changes or other singularities in a temperature-versus-time record. References are made to German commercial instruments. R. Betchov, USA

925. **Heidmann, M. F., and Priem, R. J., A modified sodium-line reversal technique for the measurement of combustion temperatures in rocket engines,** *J. Amer. Rocket Soc.* **23,** 4, 248–253, July-Aug. 1953.

Two light interrupters of differing frequencies, one after tungsten filament source and one after flame, permit convenient application of photomultiplier, amplifier, and oscillograph. Authors' summary states: "The effect of oxidant-fuel ratio on axial temperature distribution for a single two-on-one impingement type injector utilizing liquid oxygen and alcohol as propellants was evaluated." S. Corrsin, USA

926. **Graves, C. C., Combustion of single isooctane drops in various quiescent oxygen-nitrogen atmospheres,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 759–788, 1953.

It has been previously shown that the fuel-vaporization process can appreciably limit turbojet combustor performance. A study of this process may, therefore, contribute to the understanding of the problem of low combustion efficiency at altitude, and with this in mind, the burning rates of single isooctane fuel drops were the basis of the investigation in the subject paper.

The liquid fuel drops were (1) suspended from a quartz filament in quiescent oxygen-nitrogen atmospheres of variable per cent composition, (2) ignited, and (3) photographed (of the silhouette) while burning. Burning rates were determined from the resulting photographs.

The existing theories were modified to include dissociation effects, and the drop burning rates were calculated to give results in good agreement with the measured values.

These drop burning rates were then used with other considerations to calculate the change in combustion efficiency of an entire spray with variation of oxygen concentration, but these values failed to predict the much larger measured effect in an actual combustor. R. E. Bolz, USA

927. **Frank, C. E., and Blackham, A. U., Reaction processes leading to spontaneous ignition of hydrocarbons,** *NACA TN* 2958, 27 pp., June 1953.

Analysis of products obtained by vapor-phase oxidation of isooctane, *n*-heptane, 2,2,5-trimethylhexane, and isobutane at temperatures of 350 to 550 C, contact times of 0.04 to 0.068 second in a $^1/_{16}$-in. Pyrex reactor, led to following conclusions: At temperatures where alkyl and peroxy radicals have adequate stability, hydroperoxide can be obtained as major product. At higher temperatures where peroxy radical is unstable and alkyl is

still fairly stable, carbonyl compounds are obtained as major products with olefins of secondary importance. At temperatures so high that alkyl radicals tend to decompose before peroxy radical can form, olefins and hydrogen peroxide comprise major products. Structure of hydrocarbon influences not only ease of oxidative attack but also stability of radicals formed.

Major products at successive stages in oxidation of isooctane comprised (a) hydrogen peroxide and olefins, and (b) formaldehyde and acetone. Failure of isooctane to yield appreciable quantities of organic peroxide and other considerations led to proposal that initial oxidative attack occurs largely at primary and secondary rather than tertiary C-H bound.

Major products at successive stages in oxidation of *n*-heptane comprised (a) organic peroxides, and (b) carbonyl compounds (mainly formaldehyde.) Stage (b) developed with greater ease and rapidity than in case of isooctane. Resistance to oxidative attack was in the order isobutane > isooctane > 2,2,5-trimethylhexane > *n*-heptane. Potential efficiency of hydrogen peroxide formation was in the order isooctane > isobutane > 2,2,5-trimethylhexane > *n*-heptane.

From authors' summary by G. H. Markstein, USA

928. **Gaebler, G. A., Combustion engines for railways, their application and economy** (in German), *ZVDI* **95**, 27, 933–943, Sept. 1953.

Author compares several engines and their thermic processes, namely, steam engine, diesel engine, Otto engine, gas turbine, and a compound process with a piston and a turbine engine, respectively, as to their efficiency and energy cost. Processes with high thermal efficiency are uneconomical because they consume expensive fuel so that the steam engine still remains competitive. Also the combustion of fuel in a power plant, i.e., the electrical traffic, is of importance. Compared with the energy cost, the costs of installation are of secondary value. The total cost is influenced effectively by the dead weight. For short distance traffic the economical efficiency can be increased by lightweight constructions (though they are expensive), especially in connection with uneconomical, e.g., diesel, engine.

H. Krüger, Germany

929. **Quinterno, E. A., General principles of thermodynamics [Principio general de la termodinamica]**, Buenos Aires, Centro Estud. Ingen., 139 pp., 1952.

Author attempts to establish a general principle of thermodynamics of which the three classical laws would be corollary. But he only succeeds in demonstrating his rather confused ideas about thermodynamics and mathematics. The book is full of logical and mathematical mistakes. We shall abridge one paragraph only to show the medium level of the book.

On page 50 author considers a system of material and radiation, and as the energy is maintained, he writes $dE_{mat} - dE_{rad} = 0$, adding: "If only we have in mind the energy generated by molecular activity, the study of the respective phenomenon constitutes the mechanical theory of heat. Then the material energy, whose changes appear in the above question, will be expressed by the vinculated energy TS. On account of the radiant energy necessary to bring the molecular energy to action, by means of the mechanism explained in the paragraph 'Generalidades,' being called 'the amount of heat' and pointed out dQ, the expression $dE_{mat} - dE_{rad} = 0$ is transformed in $d(TS) - dQ = 0$, and the general principle of thermodynamics established, therefore, the vinculated energy varies at the expense of the amount of heat and vice versa."

Now we can certainly deduce that in all transformations without radiation (e.g., an internal-combustion engine), TS must be constant (!) and furthermore that dQ is an exact differential (!!). It must seem miraculous, therefore, that the engines run. It is a deep mystery how it is possible to derive from this the three laws of thermodynamics.

Nevertheless, author states he is writing this book to facilitate understanding "this abstract conventional integral of dark interpretation, f. i., the notion of entropy." It would be better for him to study some of the many excellent treatises on the foundation of thermodynamics, such as Fowler, Kinchin, and others that have been published. J. N. Aguirre, Argentina

Heat and Mass Transfer

(See also Revs. 801, 917, 918, 919, 920, 976)

930. **Hansen, W. C., and Livovich, A. F., Thermal conductivity of refractory insulating concrete,** *J. Amer. ceram. Soc.* **36,** 11, 356–362, Nov. 1953.

The thermal conductivities and unit weights of seventeen refractory insulating concretes have been determined over the approximate temperature range 500 to 2000 F. The thermal conductivities of all these concretes increased with increase in temperature, which is usual for amorphous bodies. The aggregates used with Lummite cement were vermiculite, perlite, pumice, calcined diatomaceous earth, and expanded shale. A graph (Fig. 7) is given of the thermal conductivities at a mean temperature of 1000 F for a range of fired unit weights which should be useful in estimating the thermal conductivity of a concrete from its fired unit weight. From summary by E. E. Sechler, USA

931. **Schmidt, E., and Leidenfrost, W., Influence of electrical field upon heat transfer in a nonconducting liquid** (in German), *Forsch. Geb. Ing.-Wes.* **19,** 3, 65–80, 1953.

By means of a special apparatus, a substantial increase of thermal conductivity of some liquid dielectrics under the influence of electric fields up to 50 kV/cm has been established. With some liquids the relation is rather linear, but with the others it shows leaps, discontinuity, and hysteresis. The rate of heat transfer increases considerably with the temperature, although the thermal convection does not take place (the product $Gr \cdot Pr$ being too low, i.e., < 1200) and also the effect of the electrical polarization of molecules is negligible. It is, therefore, supposed that this phenomenon is due to the movements of greater electrically loaded unstable particles of liquid and this seems to be confirmed by some instructive schlieren photographs. The influence of changes in electrical conductivity and viscosity should be further investigated. Because the rate of d-c energy is very low, a practical application in heat-exchanger design is suggested.

O. Maštovský, Czechoslovakia

932. **Mendelssohn, K., and Rosenberg, H. M., The thermal conductivity of metals in high magnetic fields at low temperatures,** *Proc. roy. Soc. Lond.* (*A*) **218,** 1133, 190–205, June 1953.

933. **Oswald, W., Concerning an experimental setup permitting reduced test duration when determining thermal conductivity by the Poensgen plate apparatus** (in German), *Z. angew. Phys.* **5,** 4, 130–133, Apr. 1953.

In order to shorten the heating period of the Poensgen apparatus for determining thermal conductivity of building materials, a larger heat quantity is applied to the hot plate than is required in the stationary state for establishing a desired temperature difference between the plates. Then the temperature difference is kept constant automatically by photo relays, using

thermocouples and galvanometers for controlling light beams. Test duration by this method is at most only one fourth of that by the usual method. H. Tamaki, Japan

934. Lawson, D. I., and McGuire, J. H., The solution of transient heat-flow problems by analogous electrical networks, Parts I, II, *Engineer, Lond.* **196,** 5090, 5091; 217–219, 249–252, Aug. 1953.

Paper reports upon the design and application of an electrical analog apparatus using the analogy between transient-state heat conduction and inductance-free electrical circuits. This analogy, employed by Beuken, Paschkis, and others has found wide use in the solution of complex conduction problems. The present authors have employed a fast time scale, reading the result upon a cathode-ray tube. They have introduced nonlinear circuit elements to duplicate the effects of radiation and convection losses. A detailed examination of the influence on accuracy of representing the continuous actual thermal resistance by a lumped circuit resistance is presented. Several examples of problems and their solutions, especially as related to fire-resistance problems, are given. F. C. Hooper, Canada

935. Brooks, R. D., and Rosenblatt, A. L., Design and performance of liquid metal heat exchangers and steam generators for nuclear power plants, *Mech. Engng., N. Y.* **75,** 5, 363–368, May 1953.

Liquid-metal (sodium and NaK) heat-transfer data were obtained in experiments with pilot-plant scale heat exchangers and steam generators for use in nuclear-energy power plants. Heat-transfer coefficients and pressure drop are reported, details and requirements of construction discussed. H. H. Korst, USA

936. Sorokin, V. S., Variational method in the theory of convection (in Russian), *Prikl. Mat. Mekh.* **17,** 1, 39–48, Jan.-Feb. 1953.

"Liquids and gases, when unevenly heated, unlike solids, do not exist in a state of equilibrium in the gravitational field, since different densities of unevenly heated particles cause more or less complex heat movements (convections) which depend on a temperature difference.

"Equilibrium is attainable only in special cases, when an interesting phenomenon is to be observed, namely, the beginning of a wave-like heat convection when the temperature gradient reaches some critical range.

"Investigation of such cases, while of interest by itself, becomes more worthy as it throws some light on a phenomenon in environments where equilibrium is not attainable."

From author's summary by Molotov

The author sets up and solves equations for: (1) Special cases where equilibrium is attainable; (2) slow heat motion; (3) proof of existence of a temperature gradient; (4) heat convection when the derivative is 0, where all critical heat movement must satisfy some orthogonal trajectory. W. Green, USA

937. Lovell, D. J., The concept of radiation measurements, *Amer. J. Phys.* **21,** 6, 459–462, Sept. 1953.

938. Boerdijk, A. H., The value of the constant in Wien's displacement law, *Phillips Res. Rep.* **8,** 4, 291–303, Aug. 1953.

In almost all the literature on black-body radiation, a monochromatic intensity of radiation is defined as $I_\lambda = dP/d\lambda$, where P is the total power of the radiator, and λ is the wave length. This quantity serves for the statement of Planck's distribution law. A plot of I_λ vs. λ has a peak where $\lambda T = 0.2896$, a relation known as Wien's displacement law (here T is the absolute temperature).

Author points out that there are alternatives to I_λ which describe the intensity distribution as well as I_λ or better. Quantities such as $I_\nu = dP/d\nu$, where ν is the frequency, or $I_r = dP/dr$, where $dr = d\nu/\nu$, have similar meaning and are in some problems more direct in application than I_λ.

When it is asked, for instance, what temperature should be chosen so as to produce a great intensity in a given wave-length band λ_1 to λ_2 with maximum efficiency, the precise answer turns out to be the temperature for which I_r is a maximum in the given band rather than I_λ. (Author proceeds to give the complete theory, taking into account the values of λ_1 and λ_2.) Similarly, a direct comparison shows that the plot of I_r vs. r (i.e., $\ln \nu$ or $\ln \lambda$) is much more symmetrical than the conventional representation and is more conveniently transformed when the temperature changes. Displacement laws corresponding to Wien's can easily be derived for this form of the distribution and for I_ν vs. ν.

Author concludes that, in the theory of thermal radiations, the great variety of possible distribution functions has generally been overlooked. A similarly narrow restriction has not prevailed in more recent work on circuit noise and general information theory. W. Hitschfeld, Canada

939. Hampson, H., An investigation into the condensation of steam, *Instn. mech. Engrs. Proc. (B)* **1B,** 7, 282–293, 1952.

This paper presents basic data on the condensation of steam. It should be of particular interest to condenser design engineers. It describes and gives the data obtained from tests which were conducted to examine the mechanism of condensation of steam. Quantitative measurements of the heat-transfer rates were made for high heat loads on a flat surface. Tests were performed on five plates, including three thicknesses of copper, one of brass, and one of stainless steel. An excellent discussion is given listing the various factors affecting the practical application of the test data. A twenty-three item bibliography on the subject forms the appendix. G. P. Fusner, USA

940. Jost, W., Diffusion in solids, liquids, gases, New York, Academic Press, Inc., 1952, xi + 558 pp. $12.

Approximately half of this volume is an extremely thorough coverage of diffusion in solids. Topics include theories and kinetics of disorder in crystals, diffusion in ionic, metallic, and nonpolar crystals, energy barriers, transference numbers and conductivity, the influence of nonideality and of concentration on diffusivity, solubility and diffusion of gases in all types of solids, surface reactions on metals, etc. In addition, the fundamental laws of diffusion are studied, including integrals for systems of two and more phases, and applications of diffusion theory to gases, liquids, and thermal diffusion. There is, however, less than one page on multicomponent diffusion.

Throughout, the treatment is a skillful blend of theory, application of theory, and tabulation and evaluation of experimental results. The level is uniform and the text is concise yet extremely readable. Though primarily a reference book, it should be very valuable as a text for an advanced course. Over 2000 references are provided, as well as subject, author, and formula indexes. The literature into 1950 is covered in the text, and pertinent references into 1951 in an addendum.

This book is bound to remain the ultimate on diffusion in solids for many years, as well as very useful on gases and liquids. It is a must for any library and for all those concerned with the solid state or with diffusion. C. F. Bonilla, USA

941. Berry, V. J., Mason, D. M., and Sage, B. H., Material transfer in turbulent gas streams, *Indust. Engng. Chem.* **45,** 7, 1596–1602, July 1953.

Measurements of local concentrations and velocities, made by

means of a pitot tube sampler, and temperatures taken by a quartz-shrouded thermocouple are reported for a natural-gas flame contained in a water-cooled, approximately 4-in-diam copper tube with coaxial, annular air supply, at approach velocities in the range of 10 to 50 ft. Relative concentrations of nitrogen in the reaction zone, deduced from experimental data, compare favorably with the analytical solution of the mass-transfer equation integrated under the assumption of constant velocity and diffusivity for the stream of natural gas considered as a point source in an infinite medium with eddy transport along the axis neglected. A. K. Oppenheim, USA

942. **Karlsson, H., and Hammond, W. E., Air-preheater design as affected by fuel characteristics,** *Trans. ASME* **75,** 5, 711–718, July 1953.

Paper discusses plugging and corrosion with reference to various types of fuel and combustion efficiencies. It recommends minimum cold end temperatures for various fuels, discusses and evaluates several methods of design and control to maintain these temperatures. Finally, ways of cleaning are described and mention is made of fuel additives that inhibit high-temperature deposits and lower the dew point of the gases.

A. F. W. Langford, Australia

943. **Myers, J. W., and Corey, R. C., Furnace heat absorption in a spreader-stoker-fired steam generator. 1—Furnace heat-absorption efficiency as shown by enthalpy of gases leaving the furnace,** *Trans. ASME* **75,** 5, 909–923, July 1953.

Fifteen tests on a spreader-stoker-boiler furnace were made to relate the heat-transfer rates to the temperature drop through the wall tubes. Variations were made in load, excess air, percentage of combustion air admitted over the fuel bed, overfire-air temperature, and slag and ash deposits.

The furnace heat absorption was determined as the difference between the net heat input and the losses. The losses were the sensible heat in the products of combustion and the radiation and convection losses from the casing. The net heat input was determined by heat-balance calculations on the entire unit.

The correlation of results is discussed and one conclusion drawn is that more extensive tests would be required to evaluate fully the effect of all the possible variables.

From authors' summary by A. O. Flinner, USA

944. **Feeley, F. G., Jr., and Miller, E. C., Furnace heat absorption in a spreader-stoker-fired steam generator. 2—Variation in furnace heat absorption as shown by measurement of temperature of exposed side of furnace tubes,** *Trans. ASME* **75,** 5, 925–940, July 1953.

The distribution of heat transfer on the furnace walls is shown by isothermal and ash-coverage diagrams. The basic factors influencing over-all heat absorption of the furnace tested are rating, excess air, and slag-ash coverage. The furnace is the same as that described in part I (see preceding review) and the technique is similar. A. O. Flinner, USA

945. **Harper, D. B., and Rohsenow, W. M., Effect of rotary regenerator performance on gas-turbine-plant performance,** *Trans. ASME* **75,** 5, 759–764, July 1953.

See AMR **6,** Rev. 2345.

946. **Coppage, J. E., and London, A. L., The periodic-flow regenerator—a summary of design theory,** *Trans. ASME* **75,** 5, 779–785, July 1953.

See AMR **6,** Rev. 2612.

947. **Hansen, M., Draught production of industrial furnaces with specific regard of the Siemens Martin furnace** (in German), *Stahl u. Eisen* **73,** 13, 838–845, June 1953.

Acoustics

(See also Revs. 722, 821, 864)

948. **Mawardi, O. K., On a variational principle in acoustics,** *Acustica* **3,** 3, 187–191, 1953.

The propagation of sound is discussed in an acoustic labyrinth consisting of a tube of rectangular section; the internal partitions form a periodic structure. By the method of Green's function, author obtains a pair of simultaneous integral equations of Fredholm type. The propagation constant (complex) is the characteristic value of this equation. The Rayleigh-Ritz variation principle is used to find an approximation to this characteristic value. Author uses the known solution of an electrostatic problem [Lees, C. H., *Proc. phys. Soc.* **23,** p. 1361, 1911] in which the distance between partitions is large compared with the width of the tube. Graphs are given showing the variation of the real part of the propagation constant in a typical case.

J. M. Jackson, Scotland

949. **Bennett, W. R., The correlatograph,** *Bell Syst. tech. J.* **32,** 5, 1173–1185, Sept. 1953.

Describes design of electric-analog, correlation-function computer which is thus complementary to the well-known power-spectrum computer. Device is aimed at analysis of sound; has magnetic tape input and mechanical recording. It computes cross correlation or autocorrelation with 200 discrete values of time lag. Device analyzes short segments of input signal, thus giving a running picture of the short-term correlation function. Correlatogram is presented of the sentence: "He beats his head against the posts." G. W. Housner, USA

950. **Zatzkis, H., The sound field of a moving source,** *J. acoust. Soc. Amer.* **25,** 5, 897–898, Sept. 1953.

An infinite series is developed which gives the sound field of an extended moving source which is an oblate spheroid, flattened in direction of motion with numerical eccentricity equal to Mach number. The first term of the series agrees with the point source solution established previously. Reviewer feels that only engineering significance is a possible clue to solutions for useful source shapes. E. Ackerman, USA

951. **Nickson, A. F. B., and Muncey, R. W., Acoustic impedance measurement by the transmission-characteristic method,** *Acustica* **3,** 3, 192–198, 1953.

Transmission-characteristic method for measuring acoustic impedances has been developed to be accurate, simple, and versatile. Construction of chambers and suitable dimensions are described. Impedance of a material at various angles of incidence is given for a wide range of frequencies.

From authors' summary by P. H. Parkin, England

952. **Richards, E. J., Research on aerodynamic noise from jets and associated problems,** *J. roy. aero. Soc.* **57,** 509, 318–342, May 1953.

After two years' research work in the universities of England and elsewhere, there is need for a comprehensive review of the present position on the suppression of aerodynamic noise from jet engines. This report outlines the fundamental understanding of the problem that has been achieved, the basic experimental work

done, and the noise-suppression techniques which have been suggested.

A study is made of measured noise levels on advanced types of engines and an analysis is made of reductions required and so far achieved with the proposed noise-suppression devices. While the basic principles underlying noise formation both in subsonic and supersonic jet streams are beginning to be understood, the noise reductions so far achieved are still insufficient and warrant an extended program of research.

This report also includes helicopter-noise analyses with pressure and pulsejets, and touches on the problem of structural fatigue in the vicinity of a jet stream.

From author's summary by H. H. Hubbard, USA

953. Voĭt, S. S., Spreading of initial density perturbations in a viscous gas (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **88,** 2, 221–224, Jan. 1953.

Spherically symmetric perturbation density field $s(r, t)$ and its time rate of change $\partial s/\partial t$ are prescribed inside a sphere of radius ϵ at time $t = 0$; its linearized spreading into the outside unbounded quiescent viscous gas is described without details. The formal integral solution for $s(r, t)$ (probably obtained by Laplace transforms) is considered from the point of view of an observer moving with constant parametric speed U, thus yielding $sv(t)$. Presumably, the asymptotic behavior of the resulting simpler integrals is found by the method of steepest descent for several values of U. The qualitative discussion of the thus observed "smearing" effect due to viscosity parallels that of Lagerstrom, Cole, and Trilling [*GALCIT Rep.* March 1949, sections 2.2 and 2.5] who, however, evolved more convenient expressions for the solutions of the simpler but more basic problems of step and Dirac pulses. M. V. Morkovin, USA

954. Caldwell, J. M., Supersonic sounding instruments and methods, *Trans. Amer. Soc. civ. Engrs.* **117,** 44–58, 1952.

A brief history of the development of echo sounders is given. The distinguishing features of various basic types of sounders are discussed, together with the elements of echo-sounder operation. The inherent limitations of echo sounding are pointed out with certain supporting data to enable some of the limitations to be determined on a quantitative basis. The use of echo sounders over firm sand bottoms and over soft mud bottoms is discussed, and factual data are introduced to show the average error to be expected in repeated soundings of the same profile. A comparison is made between soundings of a selected profile as obtained by echo sounders and by lead line, and the comparative results from the two methods are given in considerable detail.

From author's summary by E. G. Fischer, USA

Soil Mechanics, Seepage

(See also Revs. 774, 831, 836)

955. Bažant, Zd., Jr., Stability of cohesionless soil in curvilinear upward seepage [Stabilita nekohesních zemin v křivočrém vzestupném prouděnf], Prague, Nakladatelství Československé Akad. Věd, 1953, 161 pp. Kčs. 24. Published by Czechoslovak Academy of Sciences.

Stability of cohesionless soil in seepage governs the depth of foundation of weirs and cofferdams. If this depth is properly determined, the expensive piping can be avoided. History of the solution of this important problem is reviewed (Chenab weir in India, 1892; E. W. Lane, K. Terzaghi, L. F. Harza, author). Solution presented in this book is based on stability by shear, assuming that the failure occurs along the circular cylindrical surface through the toe, since the seepage pressure is dangerous on the downstream side only. Mathematical solution was verified by 752 model tests carried out by author from 1948 to 1951. Comparison of the theory and the tests with stereophotographic measurements discloses that the mathematical solution is on the safe side. Description of design procedure is evolved from author's theory by using method of limit design, combining the coexistence of greatest load and of smallest strength. Design examples are demonstrated on sheeting, cofferdams, weirs, dams. Heterogeneity of soil requires solution by tests. Characteristics of author's research and new methods are summarized by T. Ježdík. J. J. Polivka, USA

956. de Josselin de Jong, G., Consolidation around pore pressure meters, *J. appl. Phys.* **24,** 7, 922–928, July 1953.

In measuring pore-water pressure in soils, the response time of the meter is affected by the necessity that pore water has to move and enter the instrument. Paper contains a theoretical investigation of soil deformation and pore-water movement, assuming various loading conditions. Study has resulted in a device for measuring pore-water pressure that has reduced the response time to a fraction of a second.

From author's summary by P. W. Werner, Sweden

957. Verigin, N. N., Drenching of the soil during irrigation by sprinkling (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **89,** 4, 627–630, Apr. 1953.

958. Motílev, Yu. L., Representation of soil creepage (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **88,** 3, 441–443, Jan. 1953.

THE FOLLOWING PAPERS (REVS. 959–970) WERE PUBLISHED IN *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, in 3 vols. 75 SFr per set.

959. Selmer-Olsen, R., On the plastic properties of the Norwegian quaternary clays, vol. I, 51–54.

Results of tests concerning liquid limit, plastic limit, plastic index, sorting, and percentage of material smaller than two micron are given. Sorting is defined as $S_0 = \log(Q_{75}/Q_{25})$ in which Q_{75} and Q_{25} are the grain sizes for the 75% and for the 25% smaller in the grain-size distribution curves.

Influence of drying upon particle-size distribution analysis and liquid limit was quite noticeable. Relations between weight percentage less than two micron and plastic limit, liquid limit, and plastic index are shown graphically. The latter appears to be the most informative one. A plot of plastic limit and sorting is also presented with a certain degree of correlation and shows that, usually, when values of sorting are less, plastic limit is larger.

A. Balloffet, Argentina

960. Bishop, A. W., and Henkel, D. J., Pore pressure changes during shear in two undisturbed clays, vol. I, 94–99.

The results are reported of two investigations in which the measurement of pore-water pressure changes during shear has aided the solution of practical problems.

In the first case, measurements were made of the residual pore pressure remaining in a saturated soil after transient application of a shear stress. The results are related to the problem of estimating the safe loads to be applied to formations and subgrades of clay.

In the second case, the pore-pressure changes in sampling and testing of normally consolidated stratum are considered and re-

lated to ways of estimating the in situ strength of natural deposits, where, in general, the horizontal and vertical stresses are not equal. From authors' summary by E. Rathgeb, Argentina

961. **Casagrande, A., Prestress induced in consolidated-quick triaxial tests,** vol. I, 106–110.

Triaxial shear tests on two clay soils are described. When tests of the consolidated-quick type were performed and pore pressures measured, the failure envelope for effective stresses was found to show greater strength than was obtained from slow, or drained, tests on the same soils. This apparent anomaly is explained on the basis that the soil in the consolidated-quick test is in a state of prestress during the shearing process, inasmuch as the σ_1/σ_3 ratio decreases throughout the test. Previous studies have shown that prestressed soils show higher strengths than normally consolidated soils for the same test conditions. Implications of using quick-consolidated and slow shear strengths for design purposes are discussed. W. G. Shockley, USA

962. **Meyerhof, G. G., The bearing capacity of foundations under eccentric and inclined loads,** vol. I, 440–445.

Author extends his recently published theory of the bearing capacity of foundations under a central vertical load to eccentric and inclined loads. First, an analysis is given for eccentric vertical loads on a horizontal foundation and is compared with the results of laboratory tests on model footings on clay and sand. In the second section the theory is extended to central inclined loads on horizontal and inclined foundations and compared with the results of some model tests on clay and sand. Finally, it is shown how these methods of analysis can be combined for foundation loads which are both eccentric and inclined, and some test results are presented.

From author's summary by R. E. Fadum, USA

963. **Mizuno, T., On the bearing power of soil under a uniformly distributed circular load,** vol. I, 446–449.

Paper extends the two-dimensional problem in a previous paper [AMR **3,** Rev. 1383] to the three-dimensional case. The transition region is divided into a number of small segments. Applying equilibrium conditions, sliding surface is drawn by means of sliding condition, and the stress components are found by Mohr's circle. The results are approximate, due to certain assumptions of the method. Bearing capacities for cohesionless soil of various ϕ values are computed and given in nondimensional graphs.

M.-L. Pei, USA

964. **Hardy, R. M., Prevention of frost heaving by injection of spent sulphite liquor,** vol. II, 103–106.

Considerable success has been achieved in preventing ice segregation due to frost action under circumstances where the soil and moisture conditions are particularly susceptible to severe heaving due to frost action. The paper reports the results of laboratory and field experimental programs extending over a period of six years. From author's summary

965. **de l'Hortet, R., and Dreyfuss, G., Bearing capacity of flexible runways** (in French), vol. II, 107–111.

The problem discussed is the following: Given an existing flexible runway of known composition, which aircraft may use it without undue stress at a given period?

It is the condition of the subgrade at foundation level (given by its California bearing ratio at the water content of the period considered) which determines whether the runway can withstand the stresses imposed by traffic and stationary aircraft. As for strains, these depend on the loads applied (single wheel load), on their distribution (track of wheels), concentration (pressure on the ground), and the number of applications.

The computation of the effect of the loads at the foundation level is made on the assumption that the loads are applied to the surface of a semi-infinite homogeneous isotropic medium. From this a "single equivalent load" is deduced, which is defined by its intensity and pressure. Examples are given for aircrafts currently in service (DC-4, Constellation, Comet, etc.). The principal strain at foundation level is deduced from the single equivalent load by a method which was explained by one of the authors at the Rotterdam Congress in 1948. This method is based on the theory of elasticity, but it introduces an empirical corrective factor drawn from CBR nomographs.

Finally, with the flexible runway defined by two parameters, thickness and bearing ratio, and an aircraft defined by the weight and pressure of the single equivalent load, it is possible by means of a readily used nomograph to determine immediately whether the aircraft can be allowed to use the runway.

From authors' summaty

966. **Chadeisson, R., Use of the electrolytic-tank method to represent any pumping test including many boundary conditions** (in French), vol. II, 208–212.

Author presents an experimental method and results of determining the average soil coefficient of permeability by using electrical flux tank analog of an actual pumping installation involving boundary conditions quite complex to be handled analytically. The actual pumping site studied presented such difficult conditions as: Heterogeneous media; an excavation of complex form near a river, also of complex path; a deep impervious base; pervious and impervious mixed strata; etc. Some of the experimental techniques are novel, but their treatment is rather brief.

Y. S. Touloukian, USA

967. **Fröhlich, O. K., The factor of safety with respect to sliding of a mass of soil along the arc of a logarithmic spiral,** vol. II, 230–233.

For a given rotating force, the resistance to sliding with constant friction and variable cohesion along a logarithmic spiral is developed in terms of moments about a median center of rotation (not asymptotic point of spiral). For constant cohesion a formula is developed for the ratio of resisting moment to rotating moment. For a ratio of 1, the center of rotation is unimportant and the moment is a function of area of sector of spiral. (Tables are available in *Proc. Hyd. Res. Bd.*, p. 473, 1949).

E. S. Barber, USA

968. **Gould, J. P., The compressibility of rolled fill materials determined from field observations,** vol. II, 239–244.

Compression curves for a variety of impervious materials have been collected for embankment consolidation by the Bureau of Reclamation. Investigated are the influence of placement characteristics, soil compressibility, and the relation between strain under low stresses to the deviation of placement moisture from optimum moisture contents. The main conclusions are that clays placed dry are sensitive to stress changes after completion of the structure and that fine sands and silts of low plasticity can be made resistant to the effects of saturation by heavy compaction and exacting moisture control. R. K. Bernhard, USA

969. **Jaspar, J. L., and Ringheim, A. S., Steel sheet piling studies,** vol. II, 264–267.

Studies were conducted to estimate the effectiveness of steel sheet piling as a cut-off wall placed through a pervious founda-

tion of an earth dam. Equations derived for the flow of water through the interlocks of various types of piling embedded in river sand were used to estimate the seepage under the dam. Based on the conditions of the tests and on those assumed in the field, it was estimated that a steel-sheet pile wall would be initially equivalent to 30 ft (9 m) of upstream impervious blanket for all interlocks loose, and to 300 ft (90m) of blanket for all interlocks slightly tight and compacted with sand. It was also assumed that the interlocks would be intact and not rusted, and that the ends of the piling would be sealed into impervious material. In time, rusting of the piling would increase its effectiveness as a seepage barrier, but it is not known if sufficient rusting would occur to warrant the cost of a steel-sheet pile wall as compared to the cost of an upstream impervious blanket.

From authors' summary

970. Nonveiller, E., The stability of slopes of dams composed of heterogeneous materials, vol. II, 268–272.

Stability analysis of slopes is generally based on cylindrical sliding surfaces. If a dam consists of two materials of different properties the failure will occur along the line of minimum resistance, which is shown as a sharp break at the border between these materials. This result has been obtained in investigations carried out by the author on models consisting of a cohesive core supported by a bank of noncohesive material.

Based on the results of tests the author suggests a new method of analysis for the stability of earth dams in heterogeneous materials. From author's summary by J. C. Geyer, USA

971. Sylwestrowicz, W., Experimental investigation of the behaviour of soil under a punch or footing, *J. Mech. Phys. Solids* **1,** 4, 258–264, 4 pp. of figs., July 1953.

Sand in 10 × 15 × 6-in. box was loaded with 2 × 6-in. plate and the displacement, at various stages of loading, of 1-in. grids of dyed sand were photographed through a glass side and compared with theory. Tests with a fine soil and modeling clay gave quite different results. E. S. Barber, USA

972. Marsland, A., Model experiments to study the influence of seepage on the stability of a sheeted excavation in sand, *Géotechnique, Lond.* **3,** 6, 223–241, June 1953.

Tests were made on loose and dense sand with various stratification in a tank 2 ft deep. Records include photographs of motion, flow lines, pressures, and failure movements observed by microscope. The models agree with theory, indicating that, for dense sand, the exit gradient is critical; while for loose sand, failure occurs when the pressure at the pile tip is sufficient to lift the sand above. Fine sand under coarse sand is generally safer than the homogeneous case, but coarse sand under fine sand, at a depth less than the excavation width, is potentially dangerous. A fine layer above the bottom of the sheeting is very dangerous.

E. S. Barber, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 895)

973. Bowden, K. F., Note on wind drift in a channel in the presence of tidal currents, *Proc. roy. Soc. Lond.* (*A*) **219,** 1139, 426–446, Oct. 1953.

Wind drift is treated as a perturbation on tidal currents for a quadratic friction term along the bottom and a constant eddy viscosity in the body of the fluid. Special solutions include both transient and steady-state conditions pertaining to sea surface elevation and currents. These solutions are essentially extensions of Ekman's classical investigation. Reviewer agrees heartily with author's concluding remark that, without observations at sea, "it seems unlikely that fundamental advances in the knowledge of wind drift can be made." W. H. Munk, USA

974. van den Dungen, F. H., Cox, J. F., and van Mieghem, J., Variations of the sea level and speed of rotation of the earth (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **39,** 1, 29–34, 1953.

Authors apply the principle of the conservation of angular momentum and observed changes in mean sea level to try to explain changes in the angular velocity of the earth. Since the major glaciers (Greenland and Antartica) are at high latitudes, the mass of their ice is relatively close to the earth's axis of rotation. When they melt, this water spreads out and raises the mean sea level at all latitudes; the redistribution of mass increases the moment of inertia of the earth and decreases the angular velocity proportionately. Authors show that the observed increase of sea level, about 10 cm since 1890, is enough to account for a decrease in the earth's angular velocity of about one part in 100 million. Changes of this magnitude have been observed by astronomical means, but the authors point out that these changes have sometimes been negative, sometimes positive. Since the change in sea level has been positive throughout the period covered, they conclude the proposed mechanism cannot account for all changes in the earth's angular velocity. They also suggest that the redistribution of weight may be great enough to produce some (unspecified) seismic manifestations. F. I. Badgley, USA

975. Adderley, E. E., The growth of raindrops in cloud, *Quart. J. roy. meteor. Soc.* **79,** 341, 380–388, July 1953.

Direct measurements of the size distribution of droplets in the raindrop size range as a function of height in clouds in the free air (as contrasted to clouds penetrated by mountains) have long been wanting in meteorology. Present paper provides such measurements made in precipitating stratus clouds, using a balloon-borne radio transmitter. A very ingenious instrumental technique is used which sorts the droplets (in size range 0.4–1.6-mm diam) impinging upon a diaphragm into size ranges and reports the number in each size range as a function of altitude.

The results from six case studies are compared with theoretical predictions based on the cloud size distribution of Best [title source, **76,** p. 34, 1950] and collection efficiencies (of drops by drops) of Langmuir [*J. Meteor.* **5,** p. 175, 1948]. It is found that the measured rates of drop growth as a function of distance fallen increase much more rapidly (by about a factor of 3–4) with increase in drop diameter than the predictions. An analysis by the author indicates that, for normally observed cloud water contents (these were not, unfortunately, measured along with the spectrum of raindrops), collection efficiencies may increase from one for raindrops in the 0.5-mm range to four at 1-mm drops.

Reviewer believes that, if this effect is real, and there seems no good reason at present to doubt its reality, the development of small-scale turbulence within the clouds might possibly increase the air-path-length of the larger drops relative to the small ones enough to produce the observed discrepancy. In any case, the work in this paper is extremely provocative and must lead to more similar measurements, with additional simultaneous data, if possible. Especially, concomitant measurements of free water would be valuable. Joanne Starr Malkus, USA

976. Cramer, H. E., and Record, F. A., The variation with height of the vertical flux of heat and momentum, *J. Meteor.* 10, 3, 219–226, June 1953.

As a test of the assumption that the Reynolds stress and the

eddy heat flux are invariant with height near the earth's surface, measurements of the eddy stress and of the vertical heat flux were made in the layer from 2 to 12 meters at a station on the Massachusetts coast. The stress measurements were determined from the product of horizontal and vertical eddying wind velocities; eddy heat flux was determined from the product of vertical wind fluctuations and temperature fluctuations. Eddy velocities were obtained from hot-wire anemometers and light bivanes mounted at four levels; temperature fluctuations were measured with fast-response thermocouples mounted at three levels. Response characteristics of all sensing elements were quite uniform and sufficiently sensitive to resolve fluctuations of period 2 seconds to several minutes at mean wind speeds above 2.5 m/sec^{-1}. Data were recorded photographically, at the rate of one frame per sec for periods in the order of 10 min. Six sets of data are presented, four of which represent land trajectories; in the remaining two sets an essentially water trajectory was obtained.

The flux data show a maximum variation from two to fourfold within the layer. Over land, the shearing stress tends to decrease with height during the day and to increase with height at night; over water, both heat flux and momentum flux tend to decrease with height and also are significantly smaller at all levels than those obtained over land.

Values are also presented for the coefficients of eddy viscosity and eddy conductivity, computed on the basis of mean wind and temperature profiles obtained with slow-response instruments at the same time and location as the fast-response data. Over land, the eddy coefficients are approximately equal near the ground; for the over-water trajectory, the eddy viscosity coefficient is considerably larger than the eddy conductivity coefficient at all levels. Also noted are values of the surface drag and of von Kármán's constant; the latter varied considerably with stability and height, with a mean value of approximately 0.4.

Reviewer believes that these careful measurements are an excellent contribution to atmospheric turbulence studies. Chief deficiency seems to be the small number of sets of data, making generalization difficult. For example, there appears to be a minimum value of the Reynolds stress near six meters; however, there are occasions on which no such minimum appears, and others in which the existence of the minimum depends upon 0.6 and 0.8 dyne cm^{-2} being significantly different.

K. H. Jehn, USA

977. **Rampey, E. M., Forecasting the speed of movement of selected cyclones along upper-air steering channels,** *J. Meteor.* 10, 3, 191–196, June 1953.

An objective method for predicting the displacement of cyclones is described and tested. Method depends on the temperature gradient in the direction of air flow directly above the cyclonic vortex. Method is empirical and no theoretical justification is suggested. Results in 72 cases indicate errors which are comparable with those of other investigators using similar methods. Errors are about one half of the errors resulting from pure extrapolation of the movement of the cyclones.

R. G. Fleagle, USA

978. **Appleman, H., The formation of exhaust condensation trails by jet aircraft,** *Bull. Amer. meteor. Soc.* **34,** 1, 14–20, Jan. 1953.

Analysis and curves are presented for determining the meteorological state of the atmosphere which gives rise to the formation of condensation trails (contrails) due to the exhaust from aircraft jet engines. The analysis is based on the assumption that contrails are composed of ice crystals which are formed from the initially produced water-vapor condensate. A graph is presented for determining the possible occurrence of a contrail as a function of the relative humidity, pressure, and temperature of the atmosphere. The analysis also gives the ratio of the mass of entrained air to the mass of the exhaust gas required for the formation or dissipation of a contrail in a given atmosphere. The author indicates that this information, together with certain data about the aircraft and its engine, can be used to give qualitatively the distance behind the aircraft that contrails will form and dissipate. The results presented are based on typical turbojet operation. The analysis can be used for calculating results for other operating conditions and for other types of engines.

J. W. Drebinger, USA

979. **Kasahara, A., The structure of a tropical cyclone in the incipient stage,** *Geophys. Mag. Tokyo* **24,** 2, 131–154, Nov. 1952.

The method of small perturbations is applied to calculate pressure perturbations for the case of an axial-symmetrical disturbance and for one of nonaxial-symmetrical disturbance. The solution can be used to find the three-dimensional structure of the meteorological elements in the initial stages of a tropical cyclone. In a numerical example it is shown that the model thus obtained can explain most of the features observed. The method is from Syōno's paper "On the development of tropical cyclones" [*Tellus* **5,** 2, 179–195, May 1953].

H. Merbt, Sweden

Lubrication; Bearings; Wear

(See also Revs. 704, 791)

980. **Gillel, F., Floating roller lubrication for journal bearings** (in German), *Eisenbahntechnik* **1,** 4, 173–177, Aug. 1953.

Author claims to have solved problem of supplying oil to the journals of railway axle boxes under all conditions of viscosity by dispensing with conventional pads and substituting a free roller which floats in an oil reservoir below the journal and is lightly held against it by buoyancy forces. The roller rotates carrying oil from the reservoir to the lower surface of the journal. Oil is carried on the surface of the journal into the loaded part of the bearing providing full film lubrication. In the author's experiments, the roller was made of glass but a light alloy roller is suggested for use in traffic. The speed of rotation of the roller was shown to decrease with increase in the viscosity of the oil used. The ratio of surface speed of the roller to that of the journal varied between $^1/_8$ to $^1/_{25}$, depending on the oil used.

F. T. Barwell, Scotland

981. **Frössel, W., Shock-resistant slide bearings** (in German), *Motortech. Z.* **14,** 6, 179–180, June 1953.

Author reviews differences between boundary and hydrodynamic forms of lubrication. He discusses the conditions necessary for the formation of a fluid film in a bearing and elaborates on the resulting pressure distribution for a statically loaded bearing. He states that load conditions in the bearings of internal-combustion engines vary in both magnitude and direction of application. Author recommends the use of a bearing having its inner surface broken into four partial bearings with oil grooves between each pad.

C. D. Strang, Jr., USA

982. **Lundberg, G., Dynamic performance analysis of ball bearings with due regard to play in the bearing** (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **18,** 4, 97–105, 1952.

Author first inquires into the variation of contact angles of grooved and oblique ball bearings with clearance and under axial load. The contact angle is the angle between the operation line

of the ball loads and a plane normal to the axis of the ball bearing.

He next deals with bearings with constant contact angles. He first calculates the distribution of the elastic compressions of the balls around the circumference of the bearing with a definite clearance arising from given axial and radial shifts of the inner ring. These clearances are due to the bearing load. From this, the associated distribution of the ball loads is determined through use of Hertz' law. It is recognized that there is a definite quantity ϵ for this distribution, which is a parameter of the loaded zone and which depends on the clearance and the shifts of the inner ring. Summing up the loads of all balls yields the total force acting on the bearing. In place of these sums, it is shown that integral expressions can be used as good approximations. Thus a definite direction of the external force is associated with each value of the parameter ϵ, and, based on tables given in the paper, it is possible to calculate ϵ and the normal and axial shifts of the inner ring, once the applied force is known. Consideration is given to both one- and two-row ball bearings.

The remainder of the paper concerns the influence of clearance on the life of a bearing. Lifetime statistics based on radial-loaded bearings without clearance suggest the following distribution function

$$\ln 1/S = (P/C)^w L_s^{w/p} \ln (1/0.9)$$

where S is relative frequency, P radial load, L_s lifetime in million rotations, C dynamic loading number = load at which 90% of the bearings have a lifetime of 1.10^6 rotations, p, w constants depending on bearing material and kind of touching between rings and balls.

In order to determine the life of a bearing with given clearance and load, it is necessary to calculate the equivalent radial load which, acting on a bearing without clearance, yields the same conditions with regard to fatigue of the bearing material. It is shown that clearance lowers the load capacity for a given bearing life.

U. Rost, Germany

983. Mertsalov, N. I., The theory of spatial mechanisms [Teoriya prostranstvennïkh mekhanizmov], Moscow, Gosud. Nauch.-Tekh. Izdat. Mashinostroit. Lit., 1951, 205 pp. (pp. 125–194). 11.40 rubles.

This review treats only chapters 7 and 8 on the lubrication theory. Chapters on the theory of mechanisms are reviewed separately [see Rev. 697 in this issue].

In chapter 7 the author treats the problem of the pressure distribution in a journal bearing due to the flow of lubricant between a pair of eccentric circles by solving the Navier-Stokes equations for the two-dimensional flow of a viscous fluid. This solution he attributes to Joukowsky and Chaplígin [cf. G. H. Wannier, *Quart. appl. Math.* **8**, 1–32, 1950; AMR **4**, Rev. 1416]. No references are given. Following this, the solution for the infinite journal bearing is worked out on the basis of the Reynolds approximation.

In the next chapter, the three-dimensional problem of the journal bearing is treated by a method also attributed to Chaplígin, though again no specific references are noted. A solution for the pressure distribution is obtained but this does not agree very well with experiment. This may be due to the approximations made or, more likely, to the difficulties entailed in carrying out the experiments to conform with the assumptions made at the start of the theoretical treatment.

E. Saibel, USA

984. Osterle, F., Charnes, A., and Saibel, E., On the solution of the Reynolds equation for slider-bearing lubrication—VI. The parallel-surface slider bearing without side leakage, *Trans. ASME* **75**, 6, 1133–1136, Aug. 1953.

See AMR 6, Rev. 3277.

Marine Engineering Problems

985. Schade, H. A., The effective breadth concept in ship-structure design, Soc. nav. Arch. mar. Engrs., Prepr. Ann. Meeting, Nov. 1953. Pap. no. 4, 15 pp.

A continuation of an earlier paper by the same author [*Trans. Soc. nav. Arch. mar. Engrs.* **59**, p. 403, 1951]. Tables are given for "effective breadth," an equivalent width of flange determined by transmission of shear forces for a number of combinations of flanges with different webs, corresponding in general with those used in ship structures. Different loading distributions are considered.

F. E. Reed, USA

986. Vedeler, G., An explanation of some new details in the rules of a classification society, *N. E. Cst. Instn. Engrs. Ship. Trans.* **70**, Part 1, 45–60, Nov. 1953.

The rules of Det Norske Veritas have been revised. The tables for determining the cross-sectional areas of decks and bottoms have been replaced by formulas. The derivation and an explanation of these formulas are given. The relative merits of transverse and longitudinal framing are given. The following problems are also discussed: (1) Stresses in bulkhead plating; (2) vertical girders on bulkheads; (3) girders on bottoms of center tanks; (4) hatch coamings and hatch end beams; (5) effective width of flanges; (6) brackets; and (7) attachments.

Marshall Holt, USA

987. Okabe, J., and Taneda, S., Measurement of the wave-making resistance of a ship by means of an electric analogy, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **1**, 4, 145–150, Dec. 1952.

Using a well-known analogy between the pressure p in an ideal fluid and the electric potential φ, author proposes to calculate the wave resistance of ships as follows: (1) Prepare a corrugated metallic plate I representing the wave pattern of a ship (from hydrodynamic calculations or experiments). (2) Fill the space between this corrugated plate and a plane plate II corresponding to a depth h at which the wave effects disappear with an electrolyte. If an electric potential is kept $\varphi = 0$ at I and $\varphi = \rho g h$ at II, its values in the electrolyte represent the pressure distribution around the model.

The proposal is void of practical value since (1) the analogy refers to the two-dimensional case only; therefore the author restricts his analogy to the transverse waves only. (2) The finding of the wave profile is the most difficult part of the problem, the resistance is a minor problem.

Nevertheless, the experiment may be useful for demonstrating the surfaces of equal pressure in the two-dimensional case.

G. P. Weinblum, Germany

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